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Part the Third.

SEVENTH EDITION.

VOLUME I.

J C Branner

OUTLINES
OF
MINERALOGY, GEOLOGY,
AND
MINERAL ANALYSIS.

BY THOMAS THOMSON, M.D.

REGIUS PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF GLASGOW, F.R.S. LONDON AND EDINBURGH, F.L.S. F.G.S. MEMBER OF THE CAMBRIDGE PHILOSOPHICAL SOCIETY, OF THE CAMBRIAN NATURAL HISTORY SOCIETY, OF THE IMPERIAL MEDICO-CHIRURGICAL AND PHARMACEUTICAL SOCIETIES OF ST. PETERSBURGH, OF THE ROYAL ACADEMY OF SCIENCES OF NAPLES, OF THE MINERALOGICAL SOCIETY OF DRESDEN, OF THE CÆSARIAN NATURAL HISTORY SOCIETY OF MOSCOW, OF THE LITERARY AND PHILOSOPHICAL AND NATURAL HISTORY SOCIETIES OF NEW YORK, OF THE NATURAL HISTORY SOCIETY OF MONTREAL, ETC. ETC.

IN TWO VOLUMES.

VOL. I.

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PREFACE.

THE work which I now offer to the public, is the result of a laborious investigation which has occupied almost the whole of my spare time during a period of about ten years. The object in view, was to ascertain the chemical constitution of the different minerals which occur on the surface of the globe. For this purpose, I subjected to a rigid analysis every species that I could procure, except those which had been already investigated with sufficient accuracy by other chemists. During the course of this investigation, I analyzed several hundred specimens, and at least as many more were subjected to analysis by the numerous pupils who attended my laboratory, not a few of whom acquired great dexterity and accuracy in analysis, and have already, or speedily will distinguish themselves as analytical chemists. During these investigations, I met with a considerable number of new species hitherto overlooked by mineralogists, chiefly in specimens from Ireland, North America, and the West of Scotland. These new species, amounting to nearly 50, will be found described in the first volume of this work.

Every true mineral species is a chemical compound, the constituents of which are united in definite proportions, and the greater number of them consist but of a very few ingredients. What makes it difficult or impossible to determine these ingredients with the requisite accuracy, is, that very few minerals are free from a mixture of foreign matter interspersed among their particles. As we cannot at present determine what constituents are essential, and what accidental by actual experiment, we are left in some measure to conjecture, and I have no doubt that I have more than once drawn wrong conclusions from my analysis, respecting the true chemical constitution of the minerals analyzed. I endeavoured, where that was in my power, to examine the same mineral species from different localities. Those constituents which were never wanting, were considered as essential, while those that were wanting in certain individuals, were considered as accidental impurities. But even this method, though at first sight plausible, if not satisfactory, fails in some of the most common mineral species, as *pyroxene*, *amphibole*, and *garnet*, in which we find minerals having the same crystalline form, and yet differing completely in their composition. This is ascribed by modern chemists to what they call *isomorphism* of certain constituents of minerals. Isomorphous bodies may be substituted for each other in the same mineral without any alteration in the crystalline form, and consequently without altering the species. I am rather inclined to believe, that in these cases, two or more species having nearly the same crystalline form, have been confounded together, or occur naturally mixed with each other, in consequence of the similarity of their form. But the subject still requires a more rigid investigation.

The Geological outline which constitutes the first part of the second volume, has been added, to enable the chemical reader to judge of the position of the various minerals, and thus be the better enabled to draw conclusions respecting the accidental impurities which occur in each. At present, *geology* constitutes the fashionable study in this country, and the greater number of its votaries consider mineralogy as quite unnecessary. But no mistake can be greater or more fatal to the true progress of geology. Without an accurate knowledge of minerals, we cannot judge accurately of the nature of rocks, nor distinguish them correctly from each other. The mere knowledge of fossils is considered at present as sufficient to enable a geologist to discriminate between different formations. And there can be no doubt that it is a most important element in such a determination. But it has not yet been proved, that formations may not have been deposited at the same time in distant parts of the globe, and that the fossils which they contain may be different. The animals, for example, in New South Wales and in Britain, are quite different. Hence, it is evident, that were beds formed at present from the debris of the land in each of these countries, and were they to envelope the remains of the animals of each country, these beds, though deposited at the same time, would contain quite different fossils.

The mineral analysis, which constitutes the third part of this work, has been added to enable chemists to judge of the accuracy of the analyses contained in the first part. I thought also that it might be useful to those young British chemists, who were desirous of perfecting themselves in this important branch of practical chemistry.

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OUTLINES

OF

MINERALOGY AND GEOLOGY.

THE following work is divided into three parts: The first contains a description of all the minerals, (so far as at present known,) by the aggregation of which the globe of the earth is composed. The second gives an account of the nature and position of the different rocks of which the external crust of the earth, so far as hitherto penetrated, is composed. In the third, the methods are detailed by which minerals may be analyzed, and their different constituents determined. The subject treated of in the first of these parts is called *Mineralogy*, that treated of in the second, *Geology*, and in the third, *The Analysis of Minerals*.

PART I.

OF MINERALOGY.

INTRODUCTION.

THE term *mineral* is applied to all the solid materials of the globe, when these materials are *homogeneous*, or composed of one substance aggregated together in masses, as is the case with *sulphur*, *iron*, *antimony*, *diamond*, &c., or when they are composed of two or more constituents united together in chemical proportions. Thus, *iron pyrites* is a compound of 1 atom of *iron* and 2 atoms of *sulphur; sulphide of antimony* is a compound of 1½ atom sulphur, and 1 atom antimony; *quartz*, of 1 atom silicon, and 1 atom oxygen. In like manner, *felspar* is a compound of 3 atoms *tersilicate* of *alumina*, and 1 atom of *tersilicate* of *potash*, while *albite* is composed of 3 atoms tersilicate of alumina, and 1 atom tersilicate of soda. When a mineral is not composed of constituents united together in chemical proportions, but which vary in different specimens, such minerals are considered merely as mechanical mixtures, and belong not to mineralogy, but geology.

Mineralogy may be considered as a modern science. It had made no satisfactory progress among the ancients. Theophrastus, indeed, has left us a treatise on stones; but his descriptions are so vague that we are often left to conjecture the minerals to which he alludes; and, even if all the minerals which he describes were accurately known, they would constitute but a very small portion of the mineral kingdom. In the poem on minerals, ascribed to Orpheus, the case is still worse; twenty-four different species of stones are indeed named, but no description whatever is given. Pliny has drawn up a catalogue of a considerable number of minerals; but it consists merely of the names of the species, with a few observations on the uses to which they were put. Of this catalogue, only a small number has been made out by modern mineralogists; by far the greatest portion remains quite unknown.

We can scarcely be said to have possessed any Mineral System till Cronstedt published his *System of Mineralogy*, in 1753. His descriptions are, indeed, very imperfect; but there is an attempt at a systematic arrangement. Werner, in 1773, first contrived a mineralogical nomenclature, and showed how minerals might be described in an intelligible manner to others. It was after the publication of this nomenclature that mineralogy began to improve with rapidity; and Werner himself, who had been appointed Professor of Mineralogy in the Mining Academy of Freyberg, contributed not a little to its rapid extension. He did not, indeed, publish any system of mineralogy, but he arranged minerals according to the system of Cronstedt, as he had improved it. He was indefatigable in collecting minerals, assiduous in describing them, and he drew up every year, for the use of his students, a catalogue of all known minerals, arranged in the way that he was in the habit of describing them. Copies of his lectures were taken down by his pupils, and numerous systems of mineralogy drawn up from them and published. One of the earliest of these was Emerling's, and one of the latest, and most complete, was Hoffman's *Handbuch der Mineralogie*, in four volumes octavo.

Werner added greatly to the number of mineral species; but, as in forming them, he was merely regulated by his own notions, and had never laid down any specific rules, none of his pupils were capable of forming new species. Hence his system was not susceptible of amelioration or correction, and could only therefore last during the lifetime of the original contriver of it.

Hauy first successfully investigated the mathematical structure of crystals, taking up the subject where it had been left by Romé de Lisle. He determined the primary form of every mineral, and showed how all the secondary forms were derived by simple laws of decrement from this primary form. The knowledge of these primary forms enabled him to arrange the mineral species with more precision than had been done before him. He defined a mineral species to be a substance composed of the same constituents united in the same proportions, and possessed of the same crystalline form. In fact, he was almost entirely regulated in his formation of species by the form of the crystal. The chemical composition was taken into consideration only when two minerals, having the same crystalline shape, differ in their composition. Thus the primary form of galena and of common salt is the same, both being cubes. But *galena* is a compound of *sulphur* and *lead*, while *common salt* is a compound of *chlorine* and *sodium*. They must, therefore, constitute two distinct species.

Hauy obtained his primary forms by mechanical division. Such a process in many cases cannot be adopted. When this happened, he chose that form from which the secondary forms could be deduced with the greatest simplicity; and he was often far from happy in his choice. In his measurement of crystals, he employed merely the common goniometer, which is not susceptible of giving the angle within less than half a degree of the truth. This error he corrected, by supposing the primary form which he deduced, either a regular solid, or at least perfectly symmetrical, and from this assumed primary form he deduced all the angles of the secondary crystals by trigonometrical calculations. After the invention of the reflecting *goniometer*, by Dr. Wollaston, which is capable of measuring the angles of crystals within one minute, the angles of all crystalline bodies were again examined by other mineralogists, and it was found that the angles assumed by Hauy were very seldom the true ones, differing from the real angles of the crystals frequently by several degrees. This has rendered Hauy's measurements, and even his calculations, of comparatively little value for the science of mineralogy.

Another unfortunate method adopted by Hauy was to impose a name upon every secondary crystal, and to consider each of their secondary forms as existing by itself independent of all the rest. This renders it difficult to remember all his secondary forms when they are very numerous, as happens with respect to calcareous spar, sulphate of barytes, iron pyrites, &c. It renders the perusal of his book so irksome, that it can hardly ever be undertaken without some specific object in view.

The individuals to whom we lie under the greatest obligations for the measurement of crystals in Great Britain, are Mr. Brooke and Mr. William Phillips. The former gentleman, in his Introduction to Crystallography, has given an alphabetical catalogue of minerals, to a great number of which he has affixed his own determination of the primary crystalline form. Mr. William Phillips, in his Elements of Mineralogy, has not only given the primary form of almost every mineral determined by his own measurement, but likewise figures of the most important of the secondary faces, together with tables of the angles which they form with each other, and with the primary faces. This stamps a value upon the work of no ordinary kind.

In Germany, the mathematical theory of crystals was investigated by M. Weiss; and he conceived the fortunate idea of connecting all the secondary forms with the primary form by simple laws. This makes it much easier to remember the whole, by giving a unity to the subject, which Hauy has failed to do. Most of his calculations were made from the previous measurements of Hauy; but Mohs, who was an excellent practical mineralogist, adopted nearly the same idea. He and Mr. Haidinger, who had made himself a profound master of the theory of crystals, examined anew the angles of a vast number of crystallized minerals, and founded upon these labours a system of mineralogy, which they endeavoured to make independent of every other branch of science. They arranged minerals into classes, orders, genera, and species. Every species is distinguished by a property considered as capable of accurately discriminating it from every other species. This property is called the *characteristic*. It is founded upon three characters of minerals, namely, the hardness, specific gravity, and the crystalline form.

Mohs has arranged all minerals in what he calls a *natural history* order. The object of his arrangement is to enable a beginner to discover the name of any mineral contained in the system by its characters, precisely in the same way as in botany or entomology, any plant, or insect, contained in the system may be discovered by attending to its characters. And M. Mohs considers it as a vast advantage to mineralogy to be thus freed from the trammels of Chemistry, by which it has been hitherto hampered.

It would certainly be a boon to mineralogists of no mean value, if a method could be devised to enable a student to discover the name of any mineral contained in the system. But from the very nature of minerals the discovery of such a method is attended with much greater difficulty than in the other branches of natural history, in which organized beings are arranged; because, in them the form and peculiar structure of the respective organs affords accurate and characteristic distinctions. The only thing analogous to organization in minerals is the form of the crystal; but to be able to deduce accurate distinctions from these forms requires a previous acquaintance with crystallography, which can only be obtained by the study of crystals. That is to say, that before we be in a condition to discover the names of minerals from their crystalline forms, we must be acquainted with them. Besides, minerals do not always occur crystallized; and in such cases, our *characteristic* would be totally at fault, and would leave us incapable of drawing any conclusion.

M. Mohs gets over this difficulty, by affirming, that crystallized minerals alone belong to mineralogy as a science; that amorphous minerals are mere aggregates of minute crystalline particles incapable of description or arrangement. But supposing this to be a correct view of the subject, still, if mineralogy were to be confined to mere crystallized bodies it would be divested of the greatest part of its utility; for a very great proportion of those minerals that are of the greatest utility to man, and which, therefore, it is peculiarly important to be able to distinguish from others, are seldom found in the state of regular crystals. How often do the ores of tin, copper, lead, and iron, occur in an amorphous state? And were a mineralogist incapable of distinguishing them from each other, and from other minerals, except in the rare cases when they assumed a regularly crystallized form, his knowledge would be useless as far as the important arts of mining and metallurgy are concerned.

The specific gravity is certainly a universal property; as no mineral whatever is destitute of it. And when minerals are pure, their specific gravity is pretty nearly determinate; as the range in the same mineral is never very considerable. But specific gravity alone is not sufficient to enable us to distinguish minerals from each other; because many various species have so nearly the same specific gravity, that we might be unable to determine which of five or six minerals we had got if we had no other character to guide us but the specific gravity.

The hardness in general is pretty constant in pure minerals. But our methods of determining it are but imperfect. The consequence is, that many minerals approach each other in hardness so nearly, that by that property alone we could not with accuracy distinguish them from each other.

It appears to me, that mineralogy is so closely connected with *chemistry*, and so dependent on it for its specific distinctions that it would be highly injurious to it, and, therefore, very unwise to attempt to deprive it of so important an ally. It would be nearly the same as if the Astronomer were to announce that his science was independent of Mathematics, and were, therefore, to insist upon banishing that indispensable auxiliary from his sublime science.

Every mineral species is a chemical compound, and it consists of the very same constituents united in the very same proportions. This constitutes the essence of a mineral species, and therefore it can be determined only ultimately by chemical analysis. The mere crystalline shape alone is insufficient to constitute a mineral species; because the same shape often exists when the composition is very different. And this not merely in regular mathematical figures, as the cube and octahedron, in which such a difference has been long admitted; but also in other shapes that possess no such mathematical regularity, as in *Harmotome* and *Phillipsite*, and in two minerals hitherto confounded under the common name of *chabasite*. And in the same way, various minerals at present confounded under the specific names *garnet*, *amphibole*, *pyroxene*, because their crystalline shapes agree, in reality constitute different species, being composed of different constituents.

Unless we admit that a mineral species is composed of the same constituents united in the same proportions, we destroy altogether their fixity, and bring the whole into a chaos similar to the present state of the species amphibole, pyroxene, and garnet. I have, therefore, in the following work, arranged minerals entirely upon chemical principles; and a very few observations will be sufficient to point out the views according to which this arrangement is founded.

Bodies which unite together in definite proportions belong to two distinct classes, distinguished from each other by the name of *Acids* and *Alkalies* or *Bases*. All minerals consist essentially of these two classes of bodies, either in an insulated state or united together. Hence, I divide the Mineral Kingdom into the two great classes of *Acids* and *Bases*. In the present imperfect state of our knowledge, I have thought it right to add a third class, entitled, *Neutral Bodies*, or bodies which neither possess acid nor alkaline properties. This class is only temporary, for I have no doubt that the bodies at present placed in it will hereafter find their arrangement, either among the *acids* or *bases*. But I placed the few bodies that belong to it in their present situation, because they exhibit no disposition to unite with, or at least, are never found united either to acids or bases, but simply with each other, or with a few other metals. The neutral bodies are *gold*, *platinum*, and *iridium*.

The class of acids is divided into fifteen genera, because fifteen acids or their bases exist in the mineral kingdoms. For the same reason the class of alkaline bodies is divided into 27 genera, and the class of neutrals into 3 genera.

I shall finish these introductory observations with a few observations on the most important characters by which minerals may be distinguished from each other. The three properties by far the most fixed and steady, are hardness, specific gravity, and crystalline shape. To these, therefore, we shall turn our attention in the first place.

1. *Hardness.* The hardness of minerals, no doubt, depends upon the nature of their constituents, or, at least, upon the way in which they are arranged. The ultimate atoms of bodies are, probably, all extremely hard. But their minuteness is such, that they never can become objects of our senses, except when aggregated together. The minutest particles of carbonate of lime (for example) which we can obtain, must contain both carbonic acid and lime, and probably many particles of each. But a particle of carbonic acid is a compound of three atoms, and a particle of lime of two atoms. Hence, a single integrant particle of carbonate of lime, must contain, as a minimum, 5 atoms of matter. The hardness of bodies depends chiefly upon what has been called the *attraction of aggregation*, or the force by which homogeneous bodies are attracted towards each other. This attraction seems to be in general, greatest between the particles of simple bodies. Thus, the diamond constitutes the hardest body in nature; quartz and sapphire consisting, the former of grains of silica, and the latter of particles of alumina aggregated together, are also very hard. But sulphur, arsenic, and antimony, though simple bodies, are far from hard. Those minerals which contain a considerable proportion of alumina, zirconia, yttria, and glucina, are usually hard; while lime, magnesia, barytes, and strontian, exist in comparatively soft minerals. Many of the silicates are hard.

We must carefully distinguish between *toughness* and *hardness*. By the former is meant difficult frangibility, or a resistance which the particles offer to be separated from each other. By *hardness*, is meant the property which one mineral has of scratching another, or the power which it has to resist the action of the file. When a mineral is capable of scratching another, we consider it as the harder of the two. Thus, quartz is capable of scratching felspar, while felspar is incapable of scratching quartz. Hence, we infer, that quartz is the harder of the two minerals.

It is difficult to convey an idea of the relative hardness of minerals by a long description. The method first put in practice by Kirwan, of using figures for that purpose, is more convenient than any other. He distinguished the relative hardness of minerals into 10 different degrees, that of the diamond the hardest mineral in nature being denoted by 10. Mohs has adopted the same plan, though he has neglected to mention the source whence he derived his first idea of it. But he has given us a mineral whose hardness is denoted by each of his figures. Every mineral is supposed to possess the hardness denoted by the figure, or a hardness intermediate between some two of the numbers, which, of course, will be denoted by a fraction. The following table will render the nomenclature of hardness sufficiently intelligible:—

1	denotes the hardness of	Talc.
2	— — —	Rocksalt, gypsum.
3	— — —	Calcareous spar.
4	— — —	Fluor spar.
5	— — —	Apatite or phosphate of lime.
6	— — —	Felspar or adularia.
7	— — —	Rock crystal.
8	— — —	Topaz.
9	— — —	Corundum.
10	— — —	Diamond.

These minerals are all easily procurable, and therefore may be kept on purpose, to serve as objects of comparison.

In trying the hardness of a mineral we should avoid applying a sharp pointed mineral to it for that purpose, otherwise we may sometimes be led to consider it as softer than it really is. A good way to judge of the comparative hardness of two minerals is to draw the file over each; if there be a difference in the hardness we will discover it by the way in which each will affect the file when drawn over it.

2. The specific gravity of minerals, or the weight of a given volume of each ought to depend upon the chemical composition, and the crystalline shape; for it is obvious that bodies composed of the same chemical constituents, arranged in the same way, must have the same specific gravity. This character is of importance, and often enables us to determine the species of a mineral, even when several of the other important characters are wanting; for, as the specific gravity depends upon the arrangement of the particles as well as the crystalline shape, it is obvious that the one may be considered as an index to the other.

The lightest body hitherto met with in the mineral kingdom, is the substance formerly known by the name of *mineral tallow*, and which Mr. Conybeare (probably without being aware that it had been long known) distinguished by the name of *Hatchetine*:* its specific gravity is 0·6078. The heaviest body hitherto met with in the mineral kingdom is the ore of iridium, which has a specific gravity of 19·5, or a little greater than pure hammered gold.

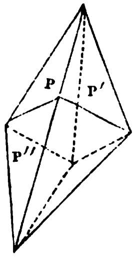
3. Minerals occur in the mineral kingdom in regular geometrical figures, the faces of which constitute planes inclined to each other at determinate angles, or at least deviating but little from each other, and constituting well defined crystals. This could hardly be the case unless the integrant particles of which each mineral is composed possessed a certain determinate shape. And unless we suppose farther that the aggregation is produced by these integrant particles always arranging themselves in one determinate way, we must suppose these particles possessed of a kind of polarity like magnets, so that certain poles attract each other, while others on the contrary repel. These mutual attractions and repulsions would undoubtedly cause them to be always aggregated together in the same way.

Were these suppositions well founded, one would expect that every mineral would always assume the very same crystalline shape; but this is very far from being the case: almost every crystallized mineral assumes different modifications of form, often so different, that they seem at first sight to have no connexion whatever with each other. Thus calcareous spar is crystallized in *rhomboids* of various kinds, in pyramidal dodecahedrons, in six-sided prisms, four-sided prisms, three-sided prisms, and in many other forms. Fluor spar occurs in cubes, and in regular octahedrons.

---

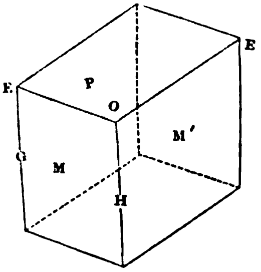
* Some mineralogists include *air* and the gaseous bodies among minerals. But it seems clear that the *aerial* as well as the *aqueous* fluids belonging to our globe ought to constitute classes quite distinct from those of minerals.

Hauy* first noted that in all such cases we can, by a cautious dissection of the crystal, extract from it a nucleus; and that this nucleus in the same mineral species has always exactly the same form. Thus, whatever be the shape of a crystal of calcareous spar, we can always extract from it an obtuse rhomboid whose faces are inclined to each other at angles of 105° 5′. Every cube of fluor spar by cautiously dissecting off the angles, yields for a nucleus a regular octahedron. The nucleus thus extracted has received the name of the *primary form* of the mineral, and characterizes the mineral species to which it belongs. Hauy showed how all the *secondary forms* (as the other forms are called,) may be deduced from the primary form by certain hypothetical laws of decrement, by means of which the connexion and dependence of all the secondary forms upon the primary forms may be mathematically deduced.



But there are certain minerals whose chemical composition is identical, that nevertheless have primary forms quite distinct from, and incompatible with each other. Thus, sulphur when found crystallized in a *native* state has the form of a double four-sided pyramid with a rhomboidal base; or it constitutes an oblique octahedron, as represented in the margin, the faces of which are thus inclined to each other,

P on P′ 106° 20′
P on P″ 143 25



When a large quantity of sulphur is melted in a crucible, and cooled slowly, pouring out the liquid portion after it has begun to congeal, pretty regular crystals will be found adhering to the inside of the vessel. These crystals have the figure represented in the margin, a right rhomboidal prism; now, this form is incompatible with the former, or cannot be deduced from it by the usual laws of decrement.

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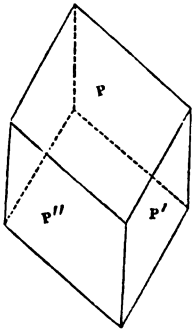
* The fact indeed had been discovered by Bergmann, or rather by Gahn, but they did not prosecute it.



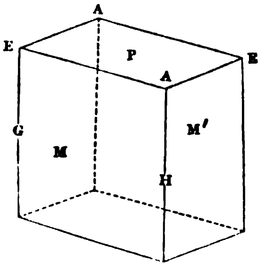
Calcareous spar has for its primary form a rhombohedron, as represented on the margin, in which

P on P′ 105° 5′.

But the primary form of the arragonite is a right rhombic prism, in which

M on M′ 116° 10′.

Yet, as far as can be determined by chemical analysis, the constituents of both are exactly the same. The two forms, however, are incompatible with each other, and the minerals differ not merely in shape, but also in their specific gravity and hardness.



Common iron pyrites has a cube for its primary form, but the primary form of white or cockscomb pyrites is a right rhomboidal prism, M on M′ 106°. Yet the constitution of both is the same, namely, 2 atoms of sulphur, and 1 atom of iron.

The minerals called *idocrase*, and *grossularite* or *green garnet*, are composed of the same constituents, namely,

1 atom silicate of alumina.
1 atom silicate of lime.

Yet the primary form of the idocrase is a right square prism, and that of the grossularite a rhomboidal dodecahedron.

From these examples we see that mere identity in chemical composition is not always sufficient to constitute identity of species. It would not do, therefore, in constituting mineral species, to be guided entirely by chemical composition. We must take into consideration the other characters; namely, crystalline form, specific gravity, and hardness; and when these differ materially, it is obvious, that notwithstanding identity in composition, we must constitute minerals so differing into different species.

It would be still more dangerous to rely upon crystalline form alone, in constructing mineral species; for nothing is more common than to find two minerals having the same crystalline form, and yet differing from each other in almost every other particular. Thus, *galena*, *iron pyrites* and *analcime* have each a cube for its primary form; yet the first is a sulphuret of lead, the second a bisulphuret of iron, and the third a compound of 3 atoms bisilicate of alumina, 1 atom bisilicate of soda, and 2 atoms water. Spinell and sal ammoniac have each the regular octahedron for the primary form, though the former is composed of alumina and magnesia, and the latter of muriatic acid and ammonia.

These facts are so well known that even the most zealous crystallographers are obliged, in forming species, to have recourse to chemical analysis, and to acknowledge that the mineral kingdom cannot be accurately arranged into species without having recourse to the assistance of the chemist.

I shall devote the remaining part of this introduction to the explanation of the system of crystallography adopted by Mohs, partly because it is now pretty generally adopted in Germany, and partly to enable the English reader to consult Haidinger's translation of Mohs's Mineralogy, which contains a great deal of most valuable information respecting crystals.

Crystals assume the following forms:

1. *Rhombohedron* or *rhomboid*, composed of six equal and similar rhombic faces, parallel two and two.

2. *Pyramid*, by which is meant two equal pyramids applied base to base. The pyramids are,

(1.) Four-sided, constituting octahedrons.

(2.) Six-sided, constituting pyramidal dodecahedrons.

(3.) Eight-sided, constituting a crystal with sixteen triangular faces.

3. The *tetrahedron*.

4. The *hexahedron* or *cube*.

5. The *dodecahedron*.

(1.) With triangular faces. A low three-sided pyramid raised on each face of the tetrahedron.

(2.) The monogrammic tetragonal dodecahedron, composed of rhombs like the garnet crystal.

(3.) The digrammic tetragonal dodecahedron, it consists of twelve trapeziums, and has the aspect of the tetrahedron.

(4.) The pentagonal dodecahedron, contained under twelve equal and similar pentagons. Of this form there are two kinds.

The first the hexahedral pentagonal dodecahedron, each face of which is a pentagon containing four equal sides, and two pairs of equal angles. The single angle is opposite to the single side.

The second the tetrahedral pentagonal dodecahedron. The faces have angles all unequal, but they have two pairs of equal sides.

6. The *icosatetrahedron*, a solid bounded by twenty-four faces. There are three kinds of icosatetrahedrons.

(1.) *Trigonal*, when the faces are triangles. Of these figures there are three kinds.

a. Tetrahedral trigonal icosatetrahedron. It may be considered as a tetrahedron upon every face of which a six-sided pyramid is raised.

b. Hexahedral trigonal icosatetrahedron. It may be considered as a cube on every face of which a low four-sided pyramid is raised.

c. Octahedral trigonal icosatetrahedron. It may be considered as an octahedron on each face of which a three-sided pyramid is raised.

(2.) *Tetragonal* when the faces are equal and similar quadrilaterals. There are two kinds of them.

a. Digrammic tetragonal icosatetrahedron. This is the form well known as that belonging to the *leucite* and the *analcime*. The faces by one of their diagonals can be divided into two isosceles triangles. It may be considered as a cube, on every face of which a four-sided pyramid of a peculiar kind is raised.

b. Trigrammic tetragonal icosahedron. The faces cannot be divided into isosceles triangles by a diagonal. It may be considered as an octahedron, on the faces of which a peculiar triangular pyramid is raised.

(3.) *Pentagonal.* The faces are pentagons with unequal angles but two pairs of equal sides.

7. The tetraconta octahedron. This figure has 48 equal and similar faces. The diamond exhibits an example of it. We may consider it as an octahedron, on each face of which a low six-sided pyramid is raised.

There is a remarkable connexion among several simple forms, depending not only on the kind, but on the dimensions of these simple forms.

Every mineral affects certain forms and avoids others. Now, the secondary forms are derived from the fundamental by *derivations.* There are four processes of derivation.

1. Tangent planes are placed upon certain edges of the given

form, and enlarged till they limit the space entirely. By this process, either simple or compound forms may be obtained.

2. The axis of the fundamental form is elongated indefinitely, but equally, both ways. Straight lines are drawn from the lateral angles to the terminal points of the axis, and planes laid upon every contiguous pair of them. The derived form is contained under these planes.

3. Planes are laid on the terminal edges of the given form. The derived form is contained under these planes.

4. The fourth process of derivation depends on the situation of a moveable plane tangent to the uppermost point of a vertical rhombohedral axis.

If a process of derivation yields a form of the same kind as the given form, the same process may be applied to this as to the given form, and so on. Thus an assemblage of similar forms is produced, called a *series.* A constant ratio exists between every two contiguous members of such a series. This is called the law of the series.

The limits of the series of those forms which contain one axis are *planes* and *prisms.* The former, when the axis becomes infinitely short; the latter, when it becomes infinitely long.

The form which serves as the base of the derivation is called the *fundamental form.* The fundamental forms adopted by Mohs, as the foundation of his method, are the four following:

1. Scalene four-sided pyramid.
2. Isosceles four-sided pyramid.
3. Rhombohedron.
4. Hexahedron.

As an example of the mode of derivation, we shall take the first of these fundamental forms, the scalene four-sided pyramid.

By applying tangent planes to the edges, and extending these planes till they intersect, (performing this process twice,) we obtain a more obtuse pyramid, with a base similar to the fundamental form.

If the derived pyramid be more obtuse than the fundamental, the axis of the fundamental form is to that of the new form as $\frac{1}{2}$: 1; if more acute, as 2 : 1.

If the derivations be continued, a series of scalene four-sided pyramids, with similar bases, will arise, whose axes will increase and decrease like the powers of the number 2.

P represents the axis of the fundamental form; P—1, P—2, P—3, &c., the decreasing axes; P+1, P+2, P+3, &c., the increasing axes.

The limits of the series are an oblique four-sided prism, whose base is equal and similar to that of the fundamental form, and a plane perpendicular to the axis. The sign of the former is $P+\infty$; of the latter, $P-\infty$. For the first takes place when the axis becomes infinitely long, and the second when it becomes infinitely short.

$\breve{P}$ and $\bar{P}$ refer to the short and long horizontal diagonals of the fundamental form.

$(\breve{P}+n)^m$ and $(\bar{P}+n)^m$ indicate two derivative prisms, (by the second law of derivation,) the first having the short axis, the last the long axis, the same as in the fundamental form. *m* denotes the number of derivations. It is always positive, and greater than 1; commonly it is 3, 4, or 5.

$\breve{P}+n$ indicates the derived member of the series from which the pyramid is obtained.

If m be supposed equal, the bases of all $(\breve{P}+n)$ and $(\bar{P}+n)$ are equal and similar to each other.

$(\bar{P}r+n)^m$ and $(\acute{P}r+n)^m$ are expressions for other four-sided pyramids.

$Pr+n$, $\breve{P}r+n$, $\bar{P}r+n$, also denote horizontal prisms.

Horizontal prisms are formed by supposing one of the horizontal diagonals of the base to become infinite in length, while the other remains. The mark above P shows which of the diagonals becomes infinite.

In four-sided isosceles triangular pyramids, the limits, when the diagonal becomes infinite, are two kinds of four-sided prisms, the one rectangular, the other oblique. This second prism is denoted thus $[P+\infty]$, putting the symbol between brackets.

From every member of the series several scalene eight-sided pyramids may be derived.

From the rhombohedron, by the first method of derivation, a series of more obtuse rhombohedrons is derived. They are designated by R, R+n.

The limits of this series are on the one hand a plane perpendicular to the axis, denoted by $R-\infty$; and on the other, a six-sided prism, denoted by $R+\infty$.

By the second method we derive from the rhombohedron a series of scalene six-sided pyramids. Their limits on the one side are unequiangular twelve-sided prisms, and on the other, plane figures, equal and similar to the horizontal projection of the fundamental form.

A moveable plane passing through the axis of a hexahedron by assuming different positions, gives origin to the octahedron, dodecahedron, trigonal icositetrahedron, hexahedron, digrammic tetragonal icositetrahedron, hexahedral trigonal icositetrahedron, and tetraconta-octahedron.

The half of the octahedron is the tetrahedron. The signs of the two tetrahedrons, into which the octahedron is divisible, are $\frac{O}{2}$ and — $\frac{O}{2}$.

The half of the hexahedral trigonal icositetrahedron is the hexahedral pentagonal dodecahedron. The crystallographical signs for these two halves are $\frac{An}{2}$, and — $\frac{An}{2}$.

The half of the octahedral trigonal icositetrahedron is the digrammic tetragonal dodecahedron. The signs for these two halves are $\frac{Bn}{2}$, and — $\frac{Bn}{2}$.

The half of the digrammic tetragonal icositetrahedron is the trigonal dodecahedron. The sign of these two halves is $\frac{Cn}{2}$, and — $\frac{Cn}{2}$.

The halves of the tetraconta-tetrahedron are,

1st. The tetrahedral trigonal icosatetrahedron, the signs of which are $\frac{Tn}{2i}$, and — $\frac{Tn}{2i}$.

2d. The trigrammic tetragonal icosatetrahedron, the signs of which are $\frac{Tn}{2ii}$, and — $\frac{Tn}{2ii}$.

3d. The pentagonal icosatetrahedron, the signs of which are $r\frac{Tn}{2}$, and $l\frac{Tn}{2}$.

The fourths of the tetraconta octahedron are the tetrahedral pentagonal dodecahedrons. For the mode of designating these fourths we refer the reader to Haidinger's edition of Mohs's Mineralogy, i. 144.

There ought to be as many systems of crystallization as there are fundamental forms; but to the four systems derived from the fundamental forms, Mohs has added two others, making the systems six. These are,

1. The rhombohedral system. Fundamental form, the rhombohedron. It is composed of rhombohedrons, six-sided pyramids, and six-sided and twelve-sided prisms.

2. The pyramidal system. Fundamental form the isosceles four-sided pyramid. It consists of isosceles four-sided pyramids, and of scalene eight-sided pyramids; besides rectangular four-sided prisms, and eight-sided prisms, with alternately equal angles.

3. The prismatic system. Fundamental form the scalene four-sided pyramid.

4. The tessular system. Fundamental form the hexahedron. To this belongs the octahedron, rhomboidal dodecahedron, isacontatetrahedron, &c.

5. The hemiprismatic system. In this several of the forms contained in it, and bearing to each other the general relations of those in the prismatic system, appear with only half the number of their faces, or in which these faces show differences in their angles, referring to an axis which is inclined in a plane perpendicular upon the base, and passing through one of its diagonals. The signs are the same as for the prismatic system, only each is divided by 2.

6. Tetarto-prismatic system. The forms which constitute this system, the scalene four-sided pyramids, show only one-fourth, and the prisms, both horizontal and vertical, only one-half the number of their faces, or these faces are distinguished from each other by their angles, which refer to an axis inclined in a plane perpendicular upon the base, and passing through neither of its diagonals.

Two or more simple forms united together constitute a *combination*. These combinations are of great importance in the study of crystals. They are called *binary*, *triple*, &c., according to the number of simple forms combined.

The combined forms must be derived from one and the same fundamental form. They must be in such positions with respect to each other, as are peculiar to the systems to which they belong.

The edges in which the faces of two different forms contained in a combination meet, are termed edges of combination.

Such is a very short sketch of the principles upon which the crystallography of Professor Mohs is founded; sufficient it is presumed to enable the reader to understand the language employed by him in his descriptions. For a fuller view of the subject we refer to the work itself.

A few observations may be proper upon some of the other characters of minerals employed in the following descriptions, besides *hardness*, *specific gravity*, *and crystalline shape.*

4. *Cleavage* is confined to those minerals which have a crystalline structure. It means indications of the faces of the primary crystal, or at least of some of them. There are some

minerals which possess cleavage so perfectly, that when struck with a hammer, they at once exhibit the crystalline faces by splitting into fragments, having each the crystalline shape of the mineral. This is remarkably the case with *calcareous spar*, which breaks naturally into rhomboids; and with *galena* which breaks naturally into small cubes. In other minerals we do not obtain a cleavage by breaking them with a hammer; but we often succeed by means of a chissel, or when we hold the mineral (if transparent) in a strong light, we frequently see the natural joints.

Sometimes minerals cleave only in one direction, as mica; sometimes in two, and sometimes in three. It is obvious, that three cleavages are requisite to determine the crystalline shape of a mineral.

5. *Fracture* means the irregular surface which appears when a mineral is broken, so that the surfaces do not constitute a cleavage. The kinds of fracture are determined according to the quality of its faces. When it exhibits cavities something like the inside of a shell, it is said to be *conchoidal.* The terms *even*, *uneven*, *splintery*, will be understood without any explanation.

6. *Lustre* refers to the quantity of light which minerals are capable of reflecting. Two things are to be considered; namely, the kind and the intensity of lustre.

The kinds are five:

(1.) Metallic, or that which metals possess.

(2.) Adamantine, or that of the diamond.

(3.) Resinous, or that which a body exhibits when besmeared with oil or fat.

(4.) Vitreous, or that of glass.

(5.) Pearly, or that of pearl, or mother of pearl.

The intensity is divided into five degrees; namely,

(1.) Splendent, when the degree of lustre is the highest, so that the mineral, if opaque, possesses the properties of a mirror.

(2.) *Shining.* A strong lustre, but not presenting a distinct image, as in the former case.

(3.) *Glistening.* When the mineral reflects light in a still more disorderly manner. Although no image appears, yet it reflects light in pretty well defined patches.

(4.) *Glimmering.* When the mineral does not reflect defined patches of light, but a mass of undefined light is spread over the glimmering surface.

(5.) *Dull.* When the mineral possesses no lustre at all.

7. *Transparency* indicates the quantity of light which passes through minerals. It is of five different degrees.

(1.) *Transparent.* When objects can be seen distinctly through the mineral.

(2.) *Semi-transparent.* When an object is visible through the mineral, but its shape cannot be distinctly made out.

(3.) *Translucent.* When light passes through the mineral, but objects cannot be seen through it.

(4.) *Translucent on the edges.* When light passes only through the thin edges of a mineral, while the interior remains perfectly dark.

(5.) *Opaque.* When no light at all passes through a mineral.

8. *Double refraction.* A black line drawn on paper appears double when viewed through transparent calcareous spar, in all positions except one. In that one position, the one line will be observed to overlap the other. In the position at right angles to that, the separation of the two lines is the greatest possible. The overlapping takes place in what is called the *principal section* of the crystal, and the greatest separation in a plane very nearly coinciding with the *equator of double refraction*, which is a plane at right angles to the crystallographic axis of the rhomboid.

If we cut off the summits of the rhomboid, and polish the new faces, we shall find that a pencil of light transmitted through these new faces is not divided into two. The line along which there is no double image is named the *axis of double refraction*, or the *optic axis*.

All minerals which belong to the *rhombohedral* and *pyramidal systems* of crystallization have only one axis of double refraction, and that coincident with the axis of symmetry of the crystal; while all minerals belonging to the *prismatic* system, and its subordinates, have two axes of double refraction; and all belonging to the *tessular* system have either three axes in equilibrio, or are otherwise so constituted, in reference to this property, that they do not display any double refraction at all. This interesting fact was discovered by Sir David Brewster.

The other terms employed in the subsequent descriptions will be understood without any farther explanation.

ARRANGEMENT AND DESCRIPTION

OF

MINERALS.

Minerals, if we arrange them according to their constituents, may be divided into three classes; namely,

Class I. Acid bases.
Class II. Alkaline bases.
Class III. Neutral bases.

The first class comprehends those bodies which become acids when combined with oxygen; the second those which become alkalies when united to the same substances; and the third those bodies which are never found in nature united to oxygen, but only united to other bases, whether acid or alkaline.

The following table, exhibiting the names and constituents of the minerals described in the following treatise will be of some utility. The composition is represented in the usual way, by symbols; and that these symbols, consisting of the first or more letters of the Latin names of the substances, may be understood, an explanation of them is inserted below.*

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* Explanation of Symbols used in the following Table, exhibiting the composition of Minerals :—

Gold	Au	Boracic acid	$\dot{\mathrm{B}}$
Silver	Ag	Barytes	Br
Arsenic	As	Bismuth	Bs
Arsenious acid	$\dot{\mathrm{A}}\mathrm{s}$	Carbon	C
Arsenic acid	$\bar{\mathrm{A}}\mathrm{s}$	Carbonic acid	$\dot{\mathrm{C}}$
Ammonia	Am	Chromium	Ch
Alumina	Al	Oxide of chromium	$\underset{\cdot}{\mathrm{C}}\mathrm{h}$
Boron	B	Chromic acid	$\dot{\mathrm{C}}\mathrm{h}$

TABLE EXHIBITING THE ARRANGEMENT AND CHEMICAL CONSTITUTION OF MINERALS.

Class I. ACID BASES.

Genus I. CARBON.

Species

1. **Diamond, C.**
2. **Graphite.**

Columbium	Cl	Nitric acid	$\dot{N}t$
Columbic acid	$\dot{C}l$	Phosphorus	Ph
Lime	Cal	Phosphoric acid	$\dot{P}h$
Cerium	Cr	Lead	Pl
Protoxide of do.	$\underline{C}r$	Palladium	Pal
Peroxide of do.	$\underset{\cdot}{C}r$	Platinum	Plt
Cobalt	Cb	Rhodium	R
Oxide of cobalt	$\underset{\cdot}{c}b$	Silica	S
Copper	Cp	Sulphur	Sl
Red oxide of do.	$\underline{C}p$	Sulphuric acid	$\dot{S}l$
Black oxide of do.	$\underset{\cdot}{C}p$	Selenium	Sel
Chlorine	Chl	Selenic acid	$\dot{S}el$
Iron	F	Antimony	St
Protoxide of iron	$\underline{f}$	Protoxide of do.	$\underline{s}t$
Peroxide of iron	$\underset{\cdot}{f}$	Deutoxide of do.	$\underset{\cdot}{s}t$
Fluoric acid	$\dot{F}l$	Tin	Sta
Glucina	G	Oxide of tin	$\underset{\cdot}{S}ta$
Mercury	H	Strontian	Str
Iridium	I	Tellurium	Tl
Potash	K	Tungsten	Tn
Lithia	L	Tungstic acid	$\dot{T}n$
Mellitic acid	$\dot{M}el$	Titanium	Tt
Molybdenum	Ml	Titanic acid	$\dot{T}t$
Molybdic acid	$\dot{M}l$	Thorina	Th
Magnesia	Mg	Vanadium	Vn
Manganese	Mn	Vanadic acid	$\dot{V}n$
Protoxide of do.	$\underline{m}n$	Uranium	Ur
Sesquioxide of do.	$\underset{\cdot}{m}n$	Protox of uranium	$\underline{U}r$
Binoxide of do.	$\underset{\cdot}{m}\underset{\cdot}{n}$	Peroxide of do.	$\underset{\cdot}{u}r$
Muriatic acid	$\dot{M}$	Zinc	Z
Soda	N	Oxide of zinc	$\underset{\cdot}{Z}$
Nickel	Nk	Zirconia	Zr
Oxide of nickel	$\underset{\cdot}{n}k$	Yttria	Y

Species

3. Anthracite.
4. Pitcoal.
5. Asphalt.
6. Elastic bitumen.
7. Retinasphaltum.
8. Scheererite.
9. Mineral tallow.
10. Amber.
11. Highgate resin.

Genus II. Boron.

Sp.

1. Boracic acid, $\bar{B}$.

Genus III. Silicon.

Sp.

1. Quartz, S.
2. Kilpatrick quartz, $18S+Aq$.
3. Chalcedony.
4. Flint.
5. Opal.
6. Jasper.
7. Basanite.

Genus IV. Phosphorus.

V. Sulphur.

Sp.

1. Native sulphur.

Genus VI. Selenium.

VII. Tellurium.

Sp.

1. Native tellurium, $11TlF$?

Genus VIII. Arsenic.

Sp.

1. Native arsenic, As.
2. Arsenious acid, $\dot{A}s$.
3. Arsenic acid, $\bar{A}s$.

Species

4. Sulphide of arsenic, $AsSl$.
5. Sesquisulphide of do., $AsSl^{1\frac{1}{2}}$.

Genus IX. ANTIMONY.

Sp.

1. Native antimony, St.
2. Arseniet of antimony, As^2St.
3. Protoxide of antimony, $\underset{\cdot}{S}t$.
4. Sesquisulphide of do., $StSl^{1\frac{1}{2}}$.
5. Red antimony, $2StSl^{1\frac{1}{2}}+\underset{\cdot}{S}l$.

Genus X. CHROMIUM.

XI. MOLYBDENUM.

Sp.

1. Bisulphide of molybd., $MlSl^2$.

Genus XII. TUNGSTEN.

XIII. COLUMBIUM.

XIV. TITANIUM.

Sp.

1. Native titanium, Tt.
2. Protoxide of do., $\underset{\cdot}{T}t$.
3. Titanic acid, $\dot{T}t$.

Genus XV. VANADIUM.

Class II. ALKALINE BASES.

Genus I. AMMONIA.

Sp.

1. Sal ammoniac, $Am\,\dot{M}$.
2. Sulphate of ammonia, $Am\,\dot{S}l$.

Genus II. POTASSIUM.

Sp.

1. Nitrate of potash, $K\dot{N}t$.

Genus III. SODIUM.

Species

1. Carbonate of soda, $N\dot{C}$.
2. Sesquicarbonate of do., $N\dot{C}^{1\frac{1}{2}}$.
3. Nitrate of soda, $N\dot{N}t$.
4. Hydrous sulphate of do., $N\dot{S}l+10Aq$.
5. Anhydrous sulphate of do., $N\dot{S}l$.
6. Borax, $N\dot{B}^2$.
7. Common salt, $NChl$.

Genus IV. LITHIUM.

V. BARIUM.

Sp.

1. Carbonate of barytes, $Br\dot{C}$.
2. Sulphate of do., $Br\dot{S}$.
3. Calcareo-sulphate of do., $Cal\dot{S}+2\frac{1}{2}Br\dot{S}$.
4. Baryto-calcite, $Cal\dot{S}+1\frac{1}{2}Br\dot{S}$.
5. Sulphato-carbonate of barytes, $Br\dot{S}+2Br\dot{C}$.

Genus VI. STRONTIUM.

Sp.

1. Green carbonate of strontian, $10Str\dot{C}+Cal\dot{C}$.
2. Brown carbonate of do., $7Str\dot{C}+Cal\dot{C}$.
3. Sulphate of strontian, $Str\dot{S}l$.
4. Baryto-sulphate of do., $7Str\dot{S}+3Br\dot{S}l$.
5. Calcareo-sulphate of do., $7Str\dot{S}+2Cal\dot{S}l$.
6. Stromnite, $4Str\dot{C}+Br\dot{S}l+\frac{1}{4}Cal\dot{C}$.

Genus VII. CALCIUM.

Sp.

1. Calcareous spar, $Cal\dot{C}$.
2. Arragonite, $Cal\dot{C}$.
3. Subsesquicarbonate of lime, $Cal^{1\frac{1}{2}}\dot{C}+Aq$.
4. Hydrous sulphate of lime, $Cal\dot{S}l+2Aq$.
5. Anhydrous sulphate of do., $Cal\dot{S}$.
6. Siliceous sulphate of do., $3Cal\dot{S}l+S$.
7. Subsesquiphosphate of do., $6Cal^{1\frac{1}{2}}Ph+CalChl$.
8. Fluor spar, $Cal\dot{F}l$.
9. Sesquisilicate of lime, $CalS^{1\frac{1}{2}}$.
10. Bisilicate of lime, $CalS^2$.
11. Wollastonite, $4CalS^2+NS^3$.

Species

12. Tersilicate of lime, $CalS^3$.
13. Dysclasite, $5CalS^4+CalS^2+9Aq$.
14. Sesquihydrous arseniate of do., $Cal\bar{A}s+1\frac{1}{2}Aq$.
15. Bisesquihydrous arseniate of do., $Cal\dot{A}s+2\frac{1}{2}Aq$.
16. Tungstate of lime, $Cal\dot{T}n$.
17. Glauberite, $Cal\dot{S}l+N\dot{S}l$.
18. Calcareo-carbonate of barytes, $Cal\dot{C}+Br\dot{C}$.
19. Bicalcareo-carbonate of barytes, $2Cal\dot{C}+Br\dot{C}$.
20. Baryto-fluate of lime, $3CalFl+Br\dot{S}$.
21. Xanthite, $6CalS+5AlS$.
22. Borosilicate of lime, $3CalS^3+Cal\dot{B}^2+2\frac{1}{2}Aq$.
23. Botryolite, $4CalS^2+CalB^2+2\frac{1}{2}Aq$.
24. Colophonite, $CalS+\underline{f}S$.
25. Ilvaite, $CalS+3\underline{f}S$.
26. Hedenbergite, $CalS^2+\underline{f}S^2$.
27. Ligurite, $2\dot{C}alS^3+AlS$.
28. Sphene, $CalS^3+Cal\dot{T}t$.
29. Raphilite, $CalS^3+(\frac{2}{3}Al+\frac{1}{3}\underline{f})S^2+(\frac{1}{2}K+\frac{1}{2}Mg)S^2$.
30. Polyadelphite, $5CalS+4(\frac{5}{6}\underline{f}+\frac{1}{6}\underline{mn})S+2MgS+AlS$.

Genus VIII. MAGNESIUM.

Sp.

1. Hydrate of magnesia, $Mg+Aq$.
2. Carbonate of do., $Mg\dot{C}$.
3. Hydro-carbonate of do., $5Mg\dot{C}^2+MgAq^{1\frac{1}{2}}$.
4. Sulphate of magnesia, $Mg\dot{S}l+7Aq$.
5. Reissite, $16N\dot{S}l+9Mg\dot{S}l$.
6. Bloedite, $3NChl+4N\dot{S}l+5Mg\dot{S}l$.
7. Biborate of magnesia, $Mg\dot{B}^2$.
8. Hydrous boracite, $Cal\dot{B}^2+Mg\dot{B}^2+5\frac{1}{2}Aq$.
9. Chrysolite, MgS.
10. Hemolite, $5MgS+11MgAq^2+Mgf$.
11. Common serpentine, $MgS+1\frac{1}{2}Aq$.
12. $\left\{\begin{array}{l}\text{Nephrite,}\\ \text{Precious serpentine,}\end{array}\right\} MgS^{1\frac{1}{2}}+1Aq$.
13. Picrosmine, $MgS^2+\frac{1}{2}Aq$.
14. Schiller spar, MgS^2+1Aq.
15. Tersilicate of magnesia, $MgS^3+\frac{1}{3}Aq$.
16. Hydrous tersilicate of do., MgS^3+AlS^3+4Aq.
17. Magnesite, MgS^3+2Aq.
18. Quincite, $4MgS^3\pm fS^3+8\frac{1}{2}Aq$.
19. Ferro-carbonate of magnesia, $9Mg\dot{C}+Cal\dot{C}$.

Species
20. Calcareo-carbonate of do., $\mathrm{Mg\dot{C}+Cal\dot{C}}$, &c.
21. Wagnerite, $\mathrm{Mg^{2}\dot{P}h}$.
22. Chondrodite, $\mathrm{6MgS+Mg\dot{F}l}$.
23. Potash-bisilicate of magnesia, $\mathrm{13MgS^{2}+KS^{2}}$.
24. Venetian talc, $\mathrm{MgS^{2}+MgS^{3}+\frac{1}{2}Aq}$.
25. White augite, $\mathrm{MgS^{2}+CalS^{2}}$.
26. Pyroxene, $\mathrm{CalS^{2}+(\frac{2}{3}Mg+\frac{1}{3}f)S^{2}}$.
27. Jeffersonite, $\mathrm{4CalS^{3}++3mnS^{3}+2fS^{3}}$.
28. Amphibole, $\mathrm{CalS^{3}+3MgS^{2}}$.
29. Norwegian tremolite, $\mathrm{2CalS^{3}+MgS^{3}}$.
30. Retinalite, $\mathrm{3MgS^{2}+2NS+8\frac{1}{2}Aq}$.
31. Hyperstene, $\mathrm{2MgS^{2}+3\underline{f}S^{2}}$.
32. Humboldtilite, $\mathrm{3CalS^{2}+MgS^{2}}$.
33. Hyalosiderite, $\mathrm{2MgS+\underline{f}^{2}S}$.
34. Anthophyllite, $\mathrm{3MgS^{2}+\underline{f}S^{2}}$.
35. Mellilite, $\mathrm{3MgS+2CalS+\underline{f}S^{2}}$.
36. Mountain cork, $\mathrm{CalS^{2}+MgS^{2}+\underline{f}S^{2}}$.
37. Hydrous anthophyllite, $\mathrm{4MgS^{3}+\underline{f}S^{3}+KS^{3}+7\frac{1}{2}Aq}$.

Genus IX. ALUMINUM.

I. *Pure or combined with Bases.*

Sp.
1. Sapphire, Al.
2. Spinell, $\mathrm{MgAl^{6}}$.
3. Ceylanite, $\mathrm{2MgAl^{4}+\underline{f}S}$.
4. Automalite or Gahnite, $\mathrm{ZAl^{4}}$.
5. Sapphirine, $\mathrm{MgAl^{4}}$.
6. Candite, $\mathrm{8MgAl^{2}+5\underline{f}Al^{2}}$.
7. Dysluite, $\mathrm{5\underline{f}Al+2\underset{\cdot}{Z}Al+1\underline{mn}Al}$.

II. *Simple Salts of Alumina.*

Sp.
1. Gibbsite or hydrate, AlAq.
2. Bihydrate of alumina, $\mathrm{AlAq.^{2}}$
3. Diaspore or dihydrate of do., $\mathrm{Al^{2}Aq}$.
4. Mellate of do., $\mathrm{AlMel+4Aq}$.
5. Aluminite, $\mathrm{Al^{2}\dot{S}l+9Aq}$.
6. Sulphate of alumina, $\mathrm{Al\dot{S}l+6Aq}$.
7. Fluellite, $\mathrm{Al\dot{F}l}$?
8. Tourquois, $\mathrm{Al^{3}\dot{P}h+2\frac{1}{2}Aq}$.
9. Andalusite, $\mathrm{Al^{2}S}$.

Species
10. **Hydrous trisilicate of alumine**, Al^3S+5Aq.
11. **Bucholzite**, AlS.
12. **Gilbertite**, $7AlS+(\frac{4\cdot75}{10}Cal+\frac{3}{10}Mg+\frac{2\cdot25}{10}f)S^2+1\frac{1}{2}Aq$.
13. **Hydrous bucholzite**, $5Al\dot{S}+1Aq$.
14. **Halloylite**, $2Al\dot{S}+Al\dot{S}^2+4Aq$.
15. **Pholerite**, $1\frac{1}{2}AlS+Aq$.
16. **Worthite**, $5AlS+Al\bar{A}q$.
17. **Cyanite**, $Al^{1\frac{1}{2}}S$.
18. **Allophane**, $2AlS+Al^2S+10Aq$.
19. **Tuesite**, $3AlS+2AlS^{1\frac{1}{2}}+3Aq$.
20. **Nacrite**, AlS^2.
21. **Fullers' earth**, AlS^2+2Aq.
22. **Davidsonite**, $AlS^{2\frac{1}{2}}$.
23. **Lenzinite**, $AlS+1Aq$.
24. **Quatersilicate of Alumina**, AlS^4.

III. *Double anhydrous aluminous Salts.*

Sp.
1. **Cryolite**, $Al\dot{F}l+N\dot{F}l$.
2. **Topaz**, $3AlS+Al\dot{F}l$.
3. **Pycnite**, $6AlS+Al\dot{F}l^2$.
4. **Ambligonite**, $2Al^2\dot{P}h+L^2\dot{P}h$.
5. **Fibrolite**, $2AlS+Al^2S$.
6. **Nepheline**, $3AlS+NS$.
7. **Sodalite**, $2AlS+NS$.
8. **Idocrase**, $AlS+CalS$.
9. **Grossularite**, $AlS+CalS$.
10. **Melanite**, $AlS+(\frac{23}{46}Mg+\frac{9}{46}\underline{f}+\frac{8}{46}Cal+\frac{6}{46}mn)S$.
11. **Garnet**, $AlS+fS$ and $CalS+\underline{f}S$.
12. **Essonite**, $\underline{f}S+4CalS+4AlS$.
13. **Brown manganese garnet**, $CalS+AlS+\underline{f}S+\underline{mn}S$.
14. **Pyrope**, $10AlS+5(\frac{10}{23}Mg+\frac{8}{23}Cal+\frac{5}{23}\underset{.}{C}hr)S+3(\frac{3}{4}\underline{f}+\frac{1}{4}\underline{mn})S^2$.
15. **Zoisite**, $2AlS+CalS$.
16. **Meionite or scapolite**, $2AlS+CalS$.
17. **Prehnite**, $2AlS+CalS^{1\frac{1}{2}}+\frac{1}{2}Aq$.
18. **Anhydrous scolezite**, $3AlS+CalS^5$.
19. **Iolite**, $9AlS+3MgS^2+fS$.
20. **Hydrous iolite**, $3AlS+1(\frac{3}{4}Mg+\frac{1}{4}f)S^2+2Aq$.
21. **Staurotide**, $4AlS+f^6S$.
22. **Gehlenite**, $3Al^{1\frac{1}{2}}S+3(\frac{8}{9}Cal+\frac{1}{9}f)^{1\frac{1}{2}}S+Aq$.
23. **Trollite**, $2AlS^2+1\frac{8}{11}Mg+\frac{2}{11}K+\frac{1}{11}f)S^2+\frac{1}{2}Aq$.
24. **Fahlunite**, $3AlS+1\frac{6}{10}Mg+\frac{3}{10}f+\frac{1}{10}mn)S^2+2Aq$.

Species

25. Anhydrous fahlunite, $3AlS+fS^2+1(\frac{2}{3}Mg+\frac{1}{3}Cal)S^2)$.
26. Leucite, $3AlS^2+KS^2$.
27. Pipe Stone, $2AlS^2+(\frac{40}{49}N+\frac{8}{49}Cal+\frac{1}{49}Mg)S^2+Aq$.
28. Murchisonite, $3AlS^{3\frac{1}{2}}+kS^{3\frac{1}{2}}$.
29. Gabronite, $3AlS^2+(K,N)S^2$.
30. Icespar, $6AlS^{2\frac{1}{2}}+KS^{2\frac{1}{2}}$.
31. Felspar, $3AlS^3+KS^3$.
32. Glassy felspar, $4AlS^3+(\frac{5}{9}K+\frac{4}{9}N)S^3$.
33. Albite, $3AlS^3+NS^3$.
34. Anorthite, $7AlS+2CalS+MgS$.
35. Labradorite, $3AlS^2+(\frac{2}{3}Cal+\frac{1}{3}N)S$.
36. Kaolin, $4(Al+f)S+(Cal+K)S$.
37. Leelite, $AlS^7+fS^7+KS^7$.
38. Spodumene, $4AlS^2+LS^2$.
39. Petalite, $2AlS^4+LS^4$.

IV. *Double hydrous aluminous Salts soluble in water.*

Sp.

1. Ammonia alum $3Al\dot{S}l+Am\dot{S}l+25Aq$.
2. Potash alum, $3Al\dot{S}l+K\dot{S}l+25Aq$.
3. Soda alum, $3Al\dot{S}l+N\dot{S}l+20Aq$.

V. *Double hydrous aluminous Sulphates and Phosphates insoluble in water.*

Sp.

1. Alumstone, $3Al^3\dot{S}l+KS\dot{l}+8Aq$.
2. Wavellite, $18Al^2\dot{P}h+Al\dot{F}l^2+29Aq$.
3. Lazulite, $4Al^2\dot{P}h+Mg^2\dot{P}h+1\frac{1}{2}Aq$.
4. Blue spar, $3Al^2\dot{P}h+Mg^2\dot{P}h$.

VI. *Double hydrous aluminous Silicates, or Zeolites.*

Sp.

1. Stellite, $4CalS^2+MgS^2+AlS+2\frac{1}{2}Aq$.
2. Thomsonite, $3AlS+CalS+2\frac{1}{2}Aq$.
3. Natrolite, $3AlS+NS^3+2Aq$.
4. Mesolite, $3AlS+(Cal,N)S^3+3Aq$.
5. Scolezite, $3AlS+CalS^3+3Aq$.
6. Zeuxite, $3AlS+f^2S+Aq$.
7. Ittnerite, $3AlS+(\frac{2}{3}N+\frac{1}{3}Cal)S+2Aq$.
8. Plinthite, $3AlS+2(\frac{7}{8}f+\frac{1}{8}Cal)S+6Aq$.
9. Bonsdorfite, $3AlS+(\frac{3}{4}Mg+\frac{1}{4}f)S^2+2Aq$.
10. Chalilite, $4(\frac{7}{8}Al+\frac{1}{8}f)S+(\frac{2}{3}Cal+\frac{1}{3}N)S+4Aq$.

Species

11. Karpholite, $7\mathrm{AlS}+3(\frac{17}{19}\mathrm{mn}+\frac{2}{19}\mathrm{f})\mathrm{S}^{1\frac{1}{2}}+6\mathrm{Aq}$.
12. Antrimolite, $5\mathrm{AlS}+(\frac{3}{4}\mathrm{Cal}+\frac{1}{4}\mathrm{K})\mathrm{S}^{3}+5\mathrm{Aq}$.
13. Glottalite, $\mathrm{AlS}^{1\frac{1}{2}}+\mathrm{CalS}+3\mathrm{Aq}$.
14. Harringtonite, $3\mathrm{AlS}^{1\frac{1}{2}}+(\frac{2}{3}\mathrm{Cal}+\frac{1}{3}\mathrm{N})\mathrm{S}+2\mathrm{Aq}$.
15. Soapstone, $\mathrm{AlS}^{1\frac{1}{2}}+2\mathrm{MgS}^{1\frac{1}{2}}+4\mathrm{Aq}$.
16. Killinite, $6\frac{1}{2}\mathrm{AlS}^{1\frac{1}{2}}+(\frac{1}{2}\mathrm{K}+\frac{1}{2}\mathrm{f})\mathrm{S}^{2}+4\mathrm{Aq}$.
17. Lomonite, $3\mathrm{AlS}^{2}+\mathrm{CalS}^{2}+5\mathrm{Aq}$.
18. Chabazite, $3\mathrm{AlS}^{2}+\mathrm{CalS}^{3}+6\mathrm{Aq}$.
19. Levyine, $3\mathrm{AlS}^{2}+(\frac{10}{11}\mathrm{Cal}+\frac{1}{11}\mathrm{Mg})\mathrm{S}^{2}+6\frac{1}{2}\mathrm{Aq}$.
20. Analcime, $3\mathrm{AlS}^{2}+\mathrm{NS}^{2}+2\mathrm{Aq}$.
21. Lehuntite, $3\mathrm{AlS}^{2}+(\frac{8}{9}\mathrm{N}+\frac{1}{9}\mathrm{Cal})\mathrm{S}^{2}+3\mathrm{Aq}$.
22. Cluthalite, $4(\frac{19}{20}\mathrm{Al}+\frac{1}{20}\mathrm{Mg})\mathrm{S}^{2}+(\frac{1}{2}\mathrm{N}+\frac{1}{2}\mathrm{f})\mathrm{S}^{2}+3\mathrm{Aq}$.
23. Hydrolite, $2\mathrm{AlS}^{3}+(\frac{1}{2}\mathrm{f}+\frac{1}{2}\mathrm{K})\mathrm{S}+9\mathrm{Aq}$.
24. Erinite, $6\mathrm{AlS}^{2}+\mathrm{fS}^{4}+16\mathrm{Aq}$.
25. Pyrophyllite, $8\mathrm{AlS}^{2}+\mathrm{MgS}^{2}+3\mathrm{Aq}$.
26. Agalmatolite, $13\mathrm{AlS}^{2}+\mathrm{KS}+4\mathrm{Aq}$.
27. Stilbite, $3\mathrm{AlS}^{3}+\mathrm{CalS}^{3}+6\mathrm{Aq}$.
28. Heulandite, $4\mathrm{AlS}^{3}+\mathrm{CalS}^{3}+6\mathrm{Aq}$.
29. Brewsterite, $3\mathrm{AlS}^{3}+(\frac{1}{3}\mathrm{Br}+\frac{2}{3}\mathrm{Str})\mathrm{S}^{3}+6\frac{1}{2}\mathrm{Aq}$.
30. Harmotome, $4\mathrm{AlS}^{3}+\mathrm{BrS}^{3}+6\mathrm{Aq}$.
31. Phillipsite, $4\mathrm{AlS}^{2}+(\mathrm{Cal},\mathrm{K})\mathrm{S}^{2}+6\mathrm{Aq}$.
32. Morvenite, $5\mathrm{AlS}^{4}+\mathrm{CalS}^{4}+11\mathrm{Aq}$.
33. Apophyllite, $7\mathrm{CalS}^{3}+\mathrm{KS}^{3}+15\mathrm{Aq}$.
34. Rhodalite, $3\mathrm{AlS}^{4}+\underline{\mathrm{f}}\mathrm{S}^{4}+16\mathrm{Aq}$.
35. Neurolite, $5\mathrm{AlS}^{4}+(\frac{2}{3}\mathrm{Cal}+\frac{1}{3}\mathrm{Mg})\mathrm{S}^{4}+2\frac{1}{2}\mathrm{Aq}$.
36. Comptonite, $8\mathrm{AlS}+2\mathrm{CalS}^{2}+\mathrm{NS}+9\mathrm{Aq}$.
37. Hexagonal talc, $5\mathrm{AlS}+4(\frac{5}{6}\mathrm{Mg}+\frac{1}{6}\mathrm{Cal})^{2}\mathrm{S}+4\mathrm{f}^{2}\mathrm{S}+7\mathrm{Aq}$.
38. Chlorite, $\mathrm{Al}^{1\frac{1}{2}}\mathrm{S}+(\frac{5}{12}\mathrm{Mg}+\frac{7}{12}\mathrm{f})^{1\frac{1}{2}}\mathrm{S}+\mathrm{Aq}$.
39. Brown chlorite, $7\mathrm{AlS}^{2}+3\frac{1}{2}\underline{\mathrm{f}}\mathrm{S}+\mathrm{KS}^{2}+\mathrm{MgS}^{2}+2\mathrm{Aq}$.

VII. *Triple aluminous Salts.*

Sp.

1. Mica, $15\mathrm{AlS}+1\frac{1}{2}\mathrm{KS}^{3}+\mathrm{fS}^{3}$.
   Black Mica, $6\mathrm{AlS}+6\mathrm{MgS}+4\mathrm{fS}^{2}+\mathrm{KS}$.
   Lepidolite, $6\mathrm{AlS}+\mathrm{LS}+\mathrm{KS}$.
2. Elœolite, $3\mathrm{AlS}+(\frac{1}{6}\mathrm{K}+\frac{5}{6}\mathrm{N})\mathrm{S}$.
3. Epidote, $4\mathrm{AlS}+3\mathrm{CalS}+2\mathrm{fS}$?
4. Axinite, $\mathrm{AlS}+(\frac{39}{100}\mathrm{Cal}+\frac{35}{100}\mathrm{f}+\frac{26}{100}\mathrm{mn})\mathrm{S}^{2}$.
5. Tourmalin,
6. Bytownite, $5\mathrm{AlS}+3(\frac{11}{12}\mathrm{Cal}+\frac{1}{12}\mathrm{Mg})\mathrm{S}^{2}+3(\frac{4}{5}\mathrm{N}+\frac{1}{5}\mathrm{f})\mathrm{S}^{2}$.
7. Vermiculite, $\mathrm{AlS}^{2}+2\mathrm{MgS}^{2}+\mathrm{fS}^{2}+3\mathrm{Aq}$.
8. Lithomarge, $7\mathrm{AlS}^{2}+\mathrm{KS}^{2}+3\mathrm{Aq}$.

Species

9. Latrobite, $5AlS+(\frac{2}{3}Cal+\frac{1}{3}K)S$
10. Withamite, $3AlS^2+2fS^2+CalS^2+Aq$.
11. Isapyre, $3AlS^2+2fS^2+2CalS$.
12. Kirwanite, $AlS^2+fS+CalS+Aq$.
13. Scorilite, $3AlS^2+CalS^2+fS^3$.
14. Sordawalite, $3AlS^2+2fS^2+2MgS+2Aq$.
15. Couzeranite, $6AlS^2+4CalS+(\frac{1}{2}K+\frac{1}{2}N)S$.

VIII. *Quadruple aluminous Salts.*

Sp.

1. Gieseckite, $10AlS+1\frac{1}{3}KS^4+(\frac{1}{6}mn+\frac{2}{6}Mg+\frac{3}{6}f)S^2+3Aq$.
2. Nutallite, $3AlS+2(Cal,f,k)S$.
3. Phyllite, $9AlS+3fS+3MgS+KS+4Aq$.
4. Huronite, $13AlS+8CalS^2+4fS^2+2MgS^2+11Aq$.
5. Erlanite, $3AlS^2+CalS^2+MgS^2+(\frac{1}{3}N+\frac{2}{3}f)S$.
6. Pinite, $8\frac{1}{2}AlS^2+KS^2+2(\frac{9}{20}f+\frac{11}{20}Mg)S+Aq$.
7. Glauconite, $3fS^{2\frac{1}{2}}+2(\frac{7}{11}Al+\frac{4}{11}K)S^{2\frac{1}{2}}+MgS^{2\frac{1}{2}}+5Aq$.
8. Mountain leather, $10AlS^3+7CalS^3+3fS^3+2MgS^2+40Aq$.
9. Pearl stone, $6AlS^5+fS^4+CalS^4+KS^4+4Aq$.
10. Saussurite, $7AlS^7+5CalS^7+2fS^7+5MgS^6$.
11. Pitchstone, $13\frac{1}{2}AlS^3+4NS^4+3CalS^4+2fS^4$.
12. Obsidian, $3AlS^9+2NS^9+2fS^9+CalS^9$.

Genus X. GLUCINUM.

Sp.

1. Phenakite, GS^2.
2. Euclase, $GS+2AlS$.
3. Emerald, GS^3+2Als^3.
4. Chrysoberyl, $5\frac{1}{2}GAl^6+fAl$.

Genus XI. YTTRIUM.

Sp.

1. Phosphate of yttria, $Y^{1\frac{1}{3}}\dot{P}h$.
2. Yttrotantalite,
    1. Black, $5Y^2\dot{C}l+f^2\dot{C}l+4\frac{1}{2}Cal^3\dot{T}n$.
    2. Yellow, $9Y^3\dot{C}l+(Cal,Ur.f)^3\dot{C}l$.
    3. Brownish black, $7Y^4\dot{C}l+(Cal,Ur,f)^4\dot{C}l$.
3. Fergusonite, $4\frac{1}{2}Y^5\dot{C}l+(Cr,Zr,Ur,f)^5\dot{C}l$.
4. Gadolinite, $2YS+(G,Cr)S$.
5. Orthite, $12\frac{1}{2}AlS+6CrS+5\frac{1}{2}fS+4\frac{1}{3}CalS+1\frac{1}{2}mnS+YS+9Aq$.
6. Pyrorthite, $2\frac{1}{2}CrS+2Al^3S+1\frac{1}{2}f^3S+Y^3S+\frac{1}{2}Cal^3S+\frac{1}{3}mn^3S$.

Genus XII. CERIUM.

Species

1. Carbonate of cerium.
2. Cerite, $CrS+Aq$.
3. Thulite, $3CrS^2+3CalS^2+1\frac{1}{2}KS^2$.
4. Fluate of cerium, $\underline{\underset{\cdot}{C}}r\dot{F}l+\underset{\cdot}{C}r\dot{F}l$.
5. Subsesquifluate of do., $\underset{:}{C}r^{1\frac{1}{2}}\dot{F}l+\frac{1}{2}Aq$.
6. Yttrocerite, $7Cal\dot{F}l+\underset{\cdot}{C}r\dot{F}l+Y\dot{F}l$.
7. Allanite, $2fS+2CrS+CalS+\frac{5}{4}AlS$.
8. Pyrochlore.

Genus XIII. ZIRCONIUM.

Sp.

1. Zircon, ZrS.
2. Sillimanite, $3AlS+ZrS$.
3. Æschynite, $5Zr\dot{T}t+2Cr\dot{T}t+Cal\dot{T}t^2+\frac{1}{2}f\dot{T}t$.
4. Eudyalite, $3\frac{1}{2}NS^2+3CalS^2+3ZrS^3+1\frac{1}{2}fS^3+\frac{1}{2}mnS3$.
5. Polymignite, $3Zr\dot{T}t+f\dot{T}t+2Y^2\dot{T}t+Cal^2\dot{T}t+\frac{1}{2}Cr^2\dot{T}t+\frac{1}{2}mn^2\dot{T}t$.

Genus XIV. THORIUM.

Sp.

1. Thorite, $2ThS+(Cal,f,mn,\ \&c.)\ S+1\frac{1}{4}Aq$.

Genus. XV. IRON.

I. *Uncombined, or united to a Simple Substance.*

Sp.

1. Native iron, F.
2. Meteoric iron, $F^{10}Nk$.
3. Magnetic iron ore, $\underline{f}\underset{\cdot}{f}^2$.
4. Specular iron ore, $\underset{\cdot}{f}$.
5. Crucite, $2Al\underset{\cdot}{f}^3+Cal\underset{-}{f}^3$.
6. Manganesian iron ore, $\underset{\cdot}{f}^3\underset{\cdot}{mn}$.
7. Franklinite, $\underline{mn}\underset{\cdot}{f}^2+Z\underset{\cdot}{f}^2$.
8. Dihydrated peroxide, $\underset{\cdot}{f}^2Aq$.
9. Hydrated peroxide, $\underset{\cdot}{f}Aq$.
10. Sulphuret of iron.

    1. $\left\{\begin{array}{l}180\ \text{Sulphuret.}\\ 1\ \text{Bisulphuret.}\end{array}\right.$

    2. $\left\{\begin{array}{l}5\ \text{Sulphuret.}\\ 1\ \text{Bisulphuret.}\end{array}\right.$

Species

3. { 2 **Sulphuret.**
   1 **Bisulphuret.**

11. **Bisulphuret of iron, FSl^2.**
12. **Radiated pyrites, FSl^2.**
13. **Sesquiarseniet of iron, $FAs^{1\frac{1}{2}}$.**

II. *Oxygen Salts of Iron.*

1. *Simple Oxygen Salts.*

Sp.

1. Carbonate of iron, $\underline{f}\dot{C}$.
2. Junkerite, $\underline{f}\dot{C}$.
3. Bisulphated peroxide of do., $\underset{\cdot}{f}\dot{S}l^2+5Aq$.
4. Sulphated peroxide of do., $\underset{\cdot}{f}S\dot{l}+5Aq$.
5. Mullicite, $\underline{f}^2\dot{P}h+4Aq$.
6. Subsesquiphosphate of iron, $\underline{f}^{1\frac{1}{2}}\dot{P}h+2\frac{1}{2}Aq$.
7. Vivianite, $\underline{f}^{1\frac{1}{2}}\dot{P}h+3\frac{1}{2}Aq$.
8. Diarsenite of iron, $\underset{\cdot}{f}^2\bar{A}s+6Aq$.
9. Subsesqui-arseniate of iron, $\underset{\cdot}{f}^{1\frac{1}{2}}\dot{A}s+3\frac{1}{3}Aq$.
10. Arseniate of iron, $\underline{f}\dot{A}s+2\underset{\cdot}{f}\dot{A}s+6Aq$.
11. Hydrousdisilicate of do., $\underline{f}^2S+\frac{3}{4}Aq$.
12. Chamoisite, $\underline{f}^2S+2Aq$.
13. Anhydrous silicate of iron, $\underline{f}S$.
14. Chronstedtite, $\underline{f}S+Aq$.
15. Hedenbergite, $\underline{f}S^{2\frac{1}{2}}+2Aq$.
16. Chloropal, $\underline{f}S^5+2Aq$.
17. Titaniate of iron, $\underline{f}\dot{T}t$.
18. Iserine, $\underline{f}\dot{T}t$.
19. Subsesquititaniate of iron, $\underline{f}^{1\frac{1}{2}}\dot{T}t$.
20. Crichtonite.
21. Nigrin, $\underset{\cdot}{f}\,Tt^5$.
22. Oxalate of iron, $\underline{f}\dot{O}$?

2. *Double Oxygen Salts.*

Sp.

1. Hydrous carbonate of iron, $8\underline{f}\dot{C}+9\underset{\cdot}{f}Aq$.
2. Magnesia-carbonate of do., $2\underline{f}\dot{C}+Mg\dot{C}$.
3. Manganeso-diphosphate of do., $\underline{f}^2\dot{P}h+\underline{mn}^2\dot{P}h$.
4. Alumina sulphate, $3\underline{f}\dot{S}+Al\dot{S}$.
5. Hetopizite, $2\underline{f}\dot{P}h+\underline{mn}^2\dot{P}h+Aq$.
6. Carbono-phosphate of iron, $6\underline{f}\dot{C}+\underline{f}^2\dot{P}h+3\underline{f}\underset{\cdot}{f}^3$.
7. Scorodite, $4\underline{f}^{1\frac{1}{2}}\dot{A}s+(\underline{mn},Cal,Mg)^{1\frac{1}{2}}\dot{A}s$.

Species
8. Cacoxenite, $\mathrm{AlS}+\underline{\mathrm{f}}^2\dot{\mathrm{P}}\mathrm{h}+6\mathrm{Aq}$.
9. Sulpho-arseniate of iron, $2\underline{\mathrm{f}}\dot{\mathrm{A}}\mathrm{s}+\underline{\mathrm{f}}^{1\frac{1}{2}}\dot{\mathrm{S}}\mathrm{l}+12\tfrac{1}{2}\mathrm{Aq}$.
10. Thraulite, $\underline{\mathrm{f}}\mathrm{S}^{1\frac{1}{2}}+2\underline{\mathrm{f}}\mathrm{S}^{1\frac{1}{2}}+5\mathrm{Aq}$.
11. Achmite, $4\underline{\mathrm{f}}\mathrm{S}^2+2\mathrm{NS}^3+(\tfrac{1}{6}\mathrm{Al}+\tfrac{1}{6}\mathrm{Mg}+\tfrac{1}{6}\mathrm{Cal}+\tfrac{5}{6}\mathrm{mn})\mathrm{S}^2$.
12. Krokidolite, $4\underline{\mathrm{f}}\mathrm{S}^3+\mathrm{NS}^{1\frac{1}{2}}+2\tfrac{1}{2}\mathrm{Aq}$.
13. Chromiron ore, $\underline{\mathrm{f}}\bar{\mathrm{C}}\mathrm{h}+\mathrm{Al}\bar{\mathrm{C}}\mathrm{h}$.
14. Arfvedsonite, $4\underline{\mathrm{f}}\mathrm{S}^3+\underline{\mathrm{m}}\mathrm{nS}^3$.
15. Knebelite, $\underline{\mathrm{f}}\mathrm{S}+\underline{\mathrm{m}}\mathrm{nS}$.
16. Columbite, $\underline{\mathrm{f}}\dot{\mathrm{C}}\mathrm{l}+\underline{\mathrm{m}}\mathrm{n}\dot{\mathrm{C}}\mathrm{l}$.
17. Wolfram, $3\underline{\mathrm{f}}\dot{\mathrm{T}}\mathrm{n}+\underline{\mathrm{m}}\mathrm{n}\dot{\mathrm{T}}\mathrm{n}$.
18. Ilmenite, $\underline{\mathrm{f}}\dot{\mathrm{T}}\mathrm{t}+\underset{\cdot}{\mathrm{f}}\dot{\mathrm{T}}\mathrm{t}$.
19. Titaniferous iron ore, ${}^4\dot{\mathrm{T}}\mathrm{t}+\underline{\mathrm{f}}^4\dot{\mathrm{T}}\mathrm{t}$. &c

3. *Triple Oxygen Salts.*

Sp.
1. Ankerite, $8\dot{\mathrm{Cal}}\mathrm{C}+5\mathrm{Mg}\dot{\mathrm{C}}+3\underline{\mathrm{f}}\dot{\mathrm{C}}$.
2. Pyrosmalite, $7\underline{\mathrm{f}}\mathrm{S}^{1\frac{1}{2}}+5\underline{\mathrm{m}}\mathrm{nS}^{1\frac{1}{2}}+\tfrac{1}{2}\mathrm{FChl}^{1\frac{1}{2}}+3\mathrm{Aq}$.
3. Commingtonite, $3\underline{\mathrm{f}}\mathrm{S}^3+1\tfrac{1}{3}\mathrm{NS}^3+\underline{\mathrm{m}}\mathrm{nS}^3+1\tfrac{1}{2}\mathrm{Aq}$.
4. Nontronite, $7\tfrac{1}{2}\underline{\mathrm{f}}\mathrm{S}^3+2\mathrm{AlS}^2+\mathrm{MgS}+20\mathrm{Aq}$.
5. Volkonskoite, $4\mathrm{ChS}^3+2\mathrm{MgS}^3+\underset{\cdot}{\mathrm{f}}\bar{\mathrm{C}}\mathrm{h}+14\mathrm{Aq}$.
6. Polylite, $9(\underline{\mathrm{f}},\underline{\mathrm{m}}\mathrm{n})\mathrm{S}+4\mathrm{AlS}+3\tfrac{1}{3}\mathrm{CalS}^2$.

III. *Sulphur Salts of Iron.*

Sp.
1. Arsenical pyrites, $\mathrm{FAS}+\mathrm{FSl}+\mathrm{ASl}$.
2. Berthierite, $1\tfrac{1}{2}\mathrm{StSl}^{1\frac{1}{2}}+\mathrm{FSl}$.

Genus XVI. MANGANESE.

I. *Combined with Simple Bodies.*

Sp.
1. Hausmannite, $\underline{\mathrm{m}}\mathrm{n}\underset{\cdot}{\mathrm{mn}}^2$.
2. Braunite, $\underset{\cdot}{\mathrm{mn}}$.
3. Manganite, $\underset{\cdot}{\mathrm{mn}}^2\mathrm{Aq}$.
4. Pyrolusite, $\underset{\cdot\cdot}{\mathrm{mn}}$.
5. Hydrous binoxide, $6\underset{\cdot\cdot}{\mathrm{mn}}+2\underset{\cdot}{\mathrm{mn}}+14\mathrm{Aq}$.
6. Hydrous sesquibinoxide, $3\underset{\cdot}{\mathrm{mn}}+2\underset{\cdot\cdot}{\mathrm{mn}}+5\mathrm{Aq}$.
7. Varvacite, $2\underset{\cdot\cdot}{\mathrm{mn}}+2\underset{\cdot}{\mathrm{mn}}+\mathrm{Aq}$.
8. Psilomelanite, $2\underset{\cdot\cdot}{\mathrm{mn}}^6\mathrm{Br}+5\underset{\cdot}{\mathrm{mn}}\mathrm{Aq}$.
9. Newkirkite, $3\underset{\cdot\cdot}{\mathrm{mn}}\mathrm{Aq}+2\underset{\cdot}{\mathrm{mn}}\underset{\cdot}{\mathrm{f}}^2$.
10. Sulphuret, $16\mathrm{MnSl}+\mathrm{MnSl}^2$.
11. Arseniet, MnAs.

II. *Oxygen Salts of Manganese.*

1. *Simple Oxygen Salts.*

Species
1. Carbonate of manganese, $\underline{m}n\dot{C}$.
2. Disilicate of do., $\underset{\cdot}{m}n^{2}S$.
3. Silicate of do., $\underline{m}nS$.
4. Sesquisilicate of do., $8\underline{m}n\underline{S}^{1\frac{1}{2}}+\underline{f}S^{5}$.
5. Bisilicate of do., $\underline{m}nS^{2}$.

2. *Double Oxygen Salts.*

Sp.
1. Huraulite, $6\underline{m}n\dot{P}h+2\underline{f}^{2}\dot{P}h+13Aq$.
2. Bustamite, $2\underline{m}nS^{2}+CalS^{2}$.
3. Ferruginous silicate of m., $3\underline{m}nS+\underline{\ }S^{1\frac{1}{2}}+2Aq$.
4. Carbosilicate of do., $\underline{m}n\dot{C}+4\underline{m}nS^{2}$.
5. Babingtonite.

3. *Triple Oxygen Salts.*

Sp.
1. Helvine $\underline{f}S^{2}+GS^{2}+6\underline{m}nS$.

Genus XVII. NICKEL.

I. *Combined with Simple Bodies.*

Sp.
1. Sulphuret of nickel, NkSl.
2. Arseniet of do., NkAs.
3. Subsequiarseniet of do., $Nk^{1\frac{1}{2}}As$.
4. Binarseniet of do., $NkAs^{2}$.
5. Antimoniet of nickel, NkSt.

II. *Oxygen Salts.*

Sp.
1. Diarseniate of nickel, $nk^{2}\dot{A}s+4Aq$.

III. *Sulphur Salts.*

Sp.
1. Sulpho-arsenite of nickel, $As^{2}Sl+Nk^{2}Sl$.
2. Sulpho-antimonite of do., $NkSt+NkSl$.

Genus XVIII. COBALT.

I. *Combined with Simple Bodies.*

Species

1. Sulphuret of cobalt, $CbSl^{1\frac{1}{2}}$.
2. Sesquiarseniet of do., $CbAs^{1\frac{1}{2}}$.
3. Binarseniet of do., $6\frac{1}{2}CbAs^2+FAs^2$.
4. Terarseniet of do., $9CbAs^3+4FAs^3$.
5. Cobalt ochre.

II. *Oxygen Salts.*

Sp.

1. Diarseniate of cobalt, $\underset{\cdot}{C}b^2\dot{A}s+4Aq$.
2. Disulphate of cobalt, $\underset{\cdot}{C}b^2\dot{S}l+9Aq$.

III. *Sulphur Salts.*

Sp.

1. Sulpho-arsenite of cobalt, $As^2Sl+\underset{\cdot}{C}b^2Sl$.

Genus XIX. ZINC.

I. *United to Simple Bodies.*

Sp.

1. Blende, ZSl.
2. Voltzinc, $4\frac{1}{2}ZSl+\underset{\cdot}{Z}$.
3. Seleniet of zinc, $3\frac{1}{2}ZSel^2+H^2Sl$.
4. Red zinc, $\underset{\cdot}{Z}^7\underset{\cdot}{m}n$.

II. *Oxygen Salts.*

Sp.

1. Anhydrous carbonate of zinc, $\underset{\cdot}{Z}\dot{C}$.
2. Hydrous dicarbonate of do., $\underset{\cdot}{Z}^2\dot{C}+2Aq$.
3. Anhydrous silicate of do., $\underset{\cdot}{z}S$.
4. Hydrous silicate of do., $\underset{\cdot}{z}S+\frac{1}{2}Aq$.
5. Sulphate of zinc, $\underset{\cdot}{z}\dot{S}l+9Aq$.
6. Hopeite.

III. *Sulphur Salts.*

Sp.

1. Marmatite, $7ZSL+3FSL$.

Genus XX. Lead.

I. *Native, or united to Simple Bodies.*

Species

1. Native lead, Pl.
2. Protoxide of lead, $\underline{\mathrm{p}}\mathrm{l}$.
3. Sesquioxide of lead, pl.
4. Sulphuret of lead, $\mathrm{Pl\dot{S}l}$.
5. Supersulphuret of do., $\mathrm{Pl^{7}Sl^{8}}$.
6. Seleniet of lead, PlSel.
7. Bitelluret of do., $\mathrm{PlTl^{2}}$.

II. *Oxygen Salts of Lead.*

1. *Simple Oxygen Salts.*

Sp.

1. Carbonate of lead, $\underline{\mathrm{p}}\mathrm{l\dot{C}}$.
2. Sulphate of lead, $\underline{\mathrm{p}}\mathrm{l\dot{S}l}$.
3. Chromate of lead, $\underline{\mathrm{p}}\mathrm{l\dot{C}h}$.
4. Melanochroite, $\underline{\mathrm{p}}\mathrm{l^{1\frac{1}{2}}\dot{C}h}$.
5. Tungstate of lead, $\underline{\mathrm{p}}\mathrm{l\dot{T}n}$.
6. Molybdate of lead, $\underline{\mathrm{p}}\mathrm{l\dot{M}l}$.
7. Trismolybdate of do., $\underline{\mathrm{p}}\mathrm{l^{3}\dot{M}l}$.

2. *Double Oxygen Salts.*

Sp.

1. Oxido-chloride of lead, $7\underline{\mathrm{p}}\mathrm{l}+3\mathrm{PlChl}$.
2. Cupreo-sulphate of do., $\underline{\mathrm{p}}\mathrm{l\dot{S}l}+\underset{\cdot}{\mathrm{c}}\mathrm{p}+\mathrm{Aq}$.
3. Sulphato-carbonate of do., $\underline{\mathrm{p}}\mathrm{l\dot{C}}+\underline{\mathrm{p}}\mathrm{l\dot{S}l}$.
4. Sulphato-tricarbonate of do., $3\underline{\mathrm{p}}\mathrm{l\dot{C}}+\underline{\mathrm{p}}\mathrm{l\dot{S}l}$.
5. Chloro-carbonate of do., $\underline{\mathrm{p}}\mathrm{l\dot{C}}+\mathrm{PlChl}$.
6. Phosphate of lead, $\mathrm{PlChl}+4\mathrm{Cal^{1\frac{1}{2}}\dot{P}h}+11\underline{\mathrm{p}}\mathrm{l^{1\frac{1}{2}}\dot{P}h}$.
7. Vanadiate of lead, $\mathrm{PlChl}+6\underline{\mathrm{p}}\mathrm{l^{3}\dot{V}n}$.
8. Arseniate of lead, $10\underset{\cdot}{\mathrm{p}}\mathrm{l^{1\frac{1}{2}}\dot{A}s}+\mathrm{PlChl}$.
9. Cuprochromate of do., $2\underset{\cdot}{\mathrm{p}}\mathrm{l\dot{C}h}+\underset{\cdot}{\mathrm{c}}\mathrm{p}$.
10. Sexaluminate of do., $\underset{\cdot}{\mathrm{p}}\mathrm{lAl^{6}}+6\mathrm{Aq}$.

3. *Triple Oxygen Salts.*

Sp.

1. Cupreous sulphato-carbonate, $7\frac{1}{2}\underset{\cdot}{\mathrm{p}}\mathrm{l\dot{S}l}+5\underset{\cdot}{\mathrm{p}}\mathrm{l\dot{C}}+4\mathrm{c}\underset{\cdot}{\mathrm{p}}\mathrm{\dot{C}}$.

Species
2. Hediphan, $4Cal^{1\frac{1}{2}}\dot{P}h+2Cal^{1\frac{1}{2}}\dot{A}s+5\underset{\cdot}{p}l^{1\frac{1}{2}}\dot{A}s+PlChl$.

III. *Sulphur Salts.*

Sp.
1. Zinkenite, $2StSl^{1\frac{1}{2}}+PlSl$.
2. Plagionite, $3StSl^{1\frac{1}{2}}+2PlSl$.
3. Jamesonite, $4StSl^{1\frac{1}{2}}+3PlSl$.
4. Feather ore, $StSl^{1\frac{1}{2}}+PlSl$.
5. Nagyag of tellurium ore, $6AuTl^{8}+7Pl^{6}+StSl$.

Genus XXI. TIN.

Sp.
1. Peroxide of tin, $Sta^{5}S$.
2. Cupreous sulphuret of do., $FSl^{2}+2CpSl+StaSl^{4}$.

Genus XXII. BISMUTH.

I. *Native, or combined with Simple Bodies.*

Sp.
1. Native bismuth, Bs.
2. Sulphuret of bismuth, $BsSl$.
3. Ferruginous arseniet of do., $3BsAs+FAs$.
4. Arsenic glance, $As^{12}Bl$.
5. Telluret of bismuth.
6. Oxide of bismuth, $7\frac{1}{2}\underset{\cdot}{b}s+\underline{f}\dot{C}+2\frac{1}{2}Aq$.

II. *Oxygen Salts.*

Sp.
1. Carbonate of bismuth.
2. Silicate of bismuth, $\underset{\cdot}{b}sS^{1\frac{1}{2}}$.

III. *Sulphur Salts.*

Sp.
1. Needle ore of bismuth, $5Bs^{2}Sl+3Cp^{2}\dot{S}l+2Pl^{2}Sl$.

Genus XXIII. COPPER.

I. *Native, or combined with Simple Bodies.*

Sp.
1. Native copper, Cp.
2. Red oxide of copper, $\underline{c}p$.
3. Black oxide of do., $\underset{\cdot}{c}p$.

Species

4. Disulphuret of do., Cp^2Sl.
5. Seleniet of copper.
6. Arseniet of do.

II. *Oxygen Salts.*

1. *Simple Oxygen Salts.*

Sp.

1. Anhydrous dicarbonate of copper, $\underset{\cdot}{c}p^2\dot{C}$.
2. Hydrous dicarbonate of do., $\underset{\cdot}{c}p^2\dot{C}+Aq$.
3. Sulphate of copper, $\underset{\cdot}{c}p\dot{S}l+5Aq$.
4. Brochantite.
5. Tetrasulphate of copper, $\underset{\cdot}{c}p^4\dot{S}l+4\frac{2}{3}Aq$.
6. Hydrous diphosphate of copper, $\underset{\cdot}{c}p^2\dot{P}h+Aq$.
7. Pelokonite.
8. Hydrous sub-bisesquiphosphate of copper, $\underset{\cdot}{c}p^{2\frac{1}{2}}\dot{P}h+3Aq$.
9. Hydrous sesquisilicate of do., $\underset{\cdot}{c}pS^{1\frac{1}{2}}+Aq$.
10. Bisilicate of copper, $\underset{\cdot}{c}pS^2+2Aq$.
11. Hydrous sub-bisesquiarseniate of do., $cp^{2\frac{1}{2}}\dot{A}s+Aq$.
12. Diarseniate of copper, $\underset{\cdot}{c}p^2\dot{A}s+4Aq$.
13. Prismatic oliven ore, $\underset{\cdot}{c}p^2\dot{A}s+\frac{1}{2}Aq$.
14. Acicular oliven ore, $\underset{\cdot}{c}p^2\dot{A}s+2Aq$.
15. Copper mica, $\underset{\cdot}{c}p^2\dot{A}s+3Aq$.
16. Octahedral arseniate of copper, $\underset{\cdot}{c}p^2\dot{A}s+5\frac{1}{2}Aq$.
17. Copper schaum, $\underset{\cdot}{c}p^{2\frac{1}{2}}\dot{A}s+4\frac{1}{2}Aq$.

2. *Double Oxygen Salts.*

Sp.

1. Hydro-carbonate of copper, $\underset{\cdot}{c}p\dot{C}+\underset{\cdot}{c}pAq$.
2. Silico-carbonate of do., $\underset{\cdot}{c}p\dot{C}+\underset{\cdot}{c}pS^2+Aq$.

III. *Chlorine Salts of Copper.*

Sp.

1. Hexmuriate of copper, $Cp^6Chl+6Aq$.

IV. *Sulphur Salts.*

Sp.

1. Variegated copper ore, $2Cp^2Sl+FSl$.
2. Copper pyrites, $FSl+CpSl$.
3. Bournonite, $StSl+PlSl+CpSl$.
4. Grey copper ore, $\left.\begin{matrix}St\\As\end{matrix}\right\}Sl+3CpSl$.

Species

5. Tenantite, $AsSl+4\frac{1}{2}CpSl$.

v. *Selenium Salts.*

Sp.

1. Eukairite, $3Cp^{2}Sel+AgSel$.

Genus XXIV. MERCURY.

Sp.

1. Native mercury, H.
2. Native amalgam, $H^{2}Ag$ & $H^{5}Ag$.
3. Sulphuret of mercury, HSl.
4. Dichloride of do., $H^{2}Chl$.
5. Chloride of do., HChl.

Genus XXV. SILVER.

i. *Native, or combined with Simple Bodies.*

Sp.

1. Native silver, $Ag^{24}Cp$.
2. Antimoniet of silver, $Ag^{4}St$ & $Ag^{3}St$.
3. Arseniet of silver.
4. Bitelluret of silver, $AgTl^{2}$.
5. Flexible sulphuret of do.
6. Sulphuret of silver, $4AgSl+AgSl^{2}$.
7. Sternbergite, $4FSl+AgSl^{2}$.
8. Seleniet of silver, $12AgSel+PlSel$.
9. Chloride of silver, AgChl.
10. Iodide of silver.

ii. *Oxygen Salts.*

Sp.

1. Carbonate of silver.

iii. *Sulphur Salts.*

Sp.

1. Sulpho-cuprite of silver, $AgSl+2Cp^{2}Sl$.
2. Brittle silver glance, $StSl^{2}+3AgSl$.
3. Dark red silver ore, $StSl^{1\frac{1}{2}}+1\frac{1}{2}AgSl$.
4. Miargirite, $11StSl^{1\frac{1}{2}}+6AgSl^{1\frac{1}{2}}$
5. Light red silver ore, $AsSl^{1\frac{1}{2}}+1\frac{1}{2}AgSl$.
6. Polybasite, $\left.\begin{matrix}St\\As\end{matrix}\right\}Sl+5\left.\begin{matrix}Ag\\Cp\end{matrix}\right\}Sl$.

Genus XXVI. URANIUM.

Species

1. Pitch ore.
2. Sulphated protoxide.
3. Sulphated peroxide.
4. Uranite, $2\underset{\cdot}{u}\dot{P}h+Cal^{1\frac{1}{2}}\dot{P}h+12Aq$.
5. Chalcolite, $2\underset{\cdot}{u}\dot{P}h+\underset{\cdot}{c}p^{1\frac{1}{2}}\dot{P}h+11Aq$.

Genus XXVII. PALLADIUM.

Sp.

1. Native palladium, Pal.
2. Seleniet of palladium.

Class III. NEUTRAL BASES.

Genus I. GOLD.

Species

1. Native gold, Au^2Ag to $Au^{56}Ag$.
2. White ore of tellurium, $7AuTl^5+5PlTl^5$.
3. Graphic ore of tellurium, $3\frac{1}{3}AuTl^5+AgTl^5$.

Genus II. PLATINUM.

Sp.

1. Native platinum, $5Plt^9F+RCp$.

Genus III. IRIDIUM.

Sp.

1. Native iridium, I^2Os.

CLASS I.

ACID BASES.

THERE are 15 acid bases, which exist in the mineral kingdom, namely:

1 Carbon,
2 Boron,
3 Silicon,
4 Phosphorus,
5 Sulphur,
6 Selenium,
7 Tellurium,
8 Arsenic,
9 Antimony,
10 Chromium,
11 Molybdenum,
12 Tungsten,
13 Columbium,
14 Titanium,
15 Vanadium.

Hence, this first class is divided into 15 genera, a genus being allotted for each base.

GENUS I.—CARBON.

Carbon exists in the mineral kingdom pure, when it is distinguished by the name of *diamond;* and nearly pure when it bears the name of *plumbago* and *anthracite*, according to its colour and situation. It occurs also combined with oxygen, constituting *carbonic acid.* This acid forms an essential constituent of 24 different minerals. The bases with which the acid is united are necessarily alkaline. Hence, these 24 species will appear in the second class under the respective alkaline bases to which they belong.

The other minerals consisting essentially of carbon, have it combined with hydrogen, and sometimes oxygen, into various bituminous or resinous substances, constituting *common pit coal*, *asphalt*, *elastic bitumen*, *scheererite*, *retinasphaltum*, *mineral tallow*, *amber*, and *Highgate resin.* Hence, this genus contains 11 different species of minerals, several of which are of great importance.

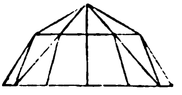
Species 1. *Diamond.*

The diamond has been known and prized for its beauty and rarity from the remotest ages. It was called *adamas* and *adamantos* by the Greeks, doubtless in consequence of its hardness. Pliny describes several species, and enumerates several fanciful properties belonging to them; but only one of these, the Indian diamond, coincides with the mineral to which we at present give that name.[*]

The diamond almost always occurs crystallized. It is seldom completely transparent. Its colours are usually white or grey. But diamonds are occasionally met with of a blue, red, brown, yellow, green, and I have seen them partly of a black colour. Of these colours, the blue and the black are the rarest. It exhibits a most beautiful play of colours when exposed to the direct rays of the sun or of a candle, especially when cut. The lustre is splendent and of a peculiar kind, to which the name of *diamond lustre*, or *adamantine lustre*, has been given. It refracts only singly; but its refractive power considerably exceeds that of most other minerals of nearly the same specific gravity.

It is *harder* than any other substance in nature, and capable, of course, of scratching every other mineral. Yet it is not difficult to break it by a blow. In consequence of this superior hardness, it can only be rubbed down or polished by means of diamond powder. The ancients were ignorant of this method of cutting diamonds, and of course were unable to polish them or cut them into facets; but employed them such as they occur in nature. In the year 1456, a citizen of Bruges, called Louis Berquen, thought of polishing them by rubbing them one against another. He collected the powder which was thus rubbed off, and spreading it by means of a greasy matter on the circumference of a wheel, this wheel being put in motion diamonds were applied to it, which by this contrivance were cut into facets, and at the same time polished. Such was the origin of the method at present employed to cut diamonds. It was highly appreciated by Charles, duke of Burgundy, who rewarded Berquen handsomely for his invention.[†]

Diamonds for ornamental purposes are cut into two shapes; namely, *rose diamonds* and *brilliants*. Rose diamonds have nearly a hemispherical form, and the hemisphere is cut into 24 triangular planes. Of course there are 7 prominent solid angles upon the hemisphere where six of the little triangles meet. This shape is represented by the figure in the margin. One of these constitutes the apex, and



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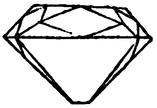
[*] Plinii Hist. Nat. lib. xxxviii. c. 4.

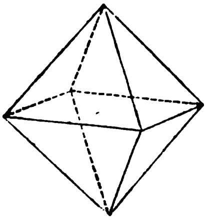
[†] Hauy; Traité de Mineralogie, iv. 438.

the other six surround it at the distance of one of the triangular faces. It is not so easy to convey an idea of what is called a *brilliant*. Some conception may be formed by supposing a natural diamond to be a regular octahedron, consisting of two four-sided pyramids with square bases applied base to base. Half the upper pyramid is cut off, and all the corners and edges converted into triangular faces. The figure of the brilliant is represented in the margin.



The specific gravity of the diamond varies somewhat in different specimens. I found that of a very fine transparent colourless diamond, in the Hunterian museum, weighing 10·825 grains, to be 3·5295. Mr. Wilson Lowry, who had in his possession a beautiful collection of crystallized diamonds, found the specific gravity 3·488. Hauy states the specific gravity of the diamond to be 3·55.[*] Mohs makes it 3·520.[†]

The structure of the diamond is straight foliated with a fourfold cleavage, parallel to the faces of the regular octahedron, which constitutes the primary form of its crystals. It occurs also frequently in cubes and in rhomboidal dodecahedrons. Indeed it is well known, that these forms are easily deducible from each other. Not unfrequently three faces may be seen, constituting a very low three-sided pyramid on each face of the primary octahedron; thus making a 24-sided figure, to which Hauy has given the name of *binaire*.



Very frequently the faces of the diamond are curved instead of being planes, as is usual with the faces of crystals. Occasionally it approaches a spherical figure, the surface being composed of 48 faces; every one of the faces of the primary octahedron being covered by a very low six-sided pyramid, three of the faces of these pyramids which are contiguous to the three angles of the octahedral face are most distinct. The other three are barely visible, and when they disappear, the diamond of course has only 24 faces, constituting the binaire of Hauy.

When the diamond is rubbed it becomes positively electric; and this happens even when it has not been cut, and though it be not insulated.

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[*] Mineralogie, iv. 19.

[†] Mohs's Mineralogy, ii. 306.

When exposed to the sun and then brought suddenly into a dark place, it phosphoresces sensibly, and this evolution of light continues for some time.

When the diamond is kept at a red heat in contact with air, it gradually burns away without leaving any residue, being wholly converted into carbonic acid gas.

Hitherto, the diamond has been found only in the torrid zone. The ancients drew all their diamonds from India. It occurs in alluvial soil in the provinces of Golconda and Visapoor, Bengal, and in the island of Borneo. It is still found in these situations, though not in such abundance as formerly. About the year 1740, diamonds were discovered in Brazil. Great quantities of them have been collected in the district of Serro dofrio, and in other places. They are obtained as in India, by washing the alluvial soil. The original repository of this precious stone is unknown; unless we consider the kind of iron ore in which it is occasionally found embedded in Brazil as of that nature.* A report has been current, that diamonds, of late years, have been discovered in the mining district of the Uralian mountains. But this report stands in need of confirmation. We are informed also, that M. Peluzzo bought three diamonds from a native of Algiers; which had been found in the sand of the river Gumil, in the province of Constantine, in Africa.†

The largest diamond known to exist, (if we except that belonging to the king of Portugal, thought by many to be only a topaz) weighed in its original state 900 carats, or 2769·3 grains.‡ By cutting, it was reduced to 279·9 carats, or 861 grains. It has the form and the size of half a hen's egg. It is mentioned by Tavernier, as in possession of the Great Mogul, and was found in the mine of Colone in 1550. What has become of this diamond of late years is unknown.

The oriental diamond purchased by the Empress Catharine II. of Russia, claims the next place. It is without flaw or fault of any kind, and weighs 193 carats, or 593·86 gr. Its form is that of a flattened ovoid, and its size that of a pigeon's egg. It is said to have been in possession of Nadir Shah. But more lately it had become one of the eyes of a Braminical idol, and was stolen by a French Grenadier, who disposed of it at a very low price. After passing through several hands, it was purchased by Catharine, for about £90,000, in ready money, and an annuity of £4000 more.

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* Some account of the constitution of that portion of Brazil which yields diamonds, will be found in Humboldt's *Essai Geognostique sur le Gisement des Roches*, p. 89.

† Poggendorff's Annalen, xxxii. 480.

‡ A carat is equal to 3·077 grains.

The Pitt, or Regent diamond, is said to have been found in Malacca. It was purchased by Mr. Pitt, an English gentleman, who was governor of Bencoolen in Sumatra. It was sold by him to the regent Duke of Orleans, for £130,000, by whom it was placed among the crown jewels of France. It is cut in the form of a brilliant, and is not only without blemish, but considered as the most beautiful diamond hitherto found. It weighs 136·25 carats, or 419¼ grains. Its value, as estimated by a commission of jewellers in 1791, is twelve millions of livres or half a million sterling.

The greater number of diamonds are very small, and so full of flaws, as to be useless for the purposes of the jeweller. They are reduced to powder, and employed in the cutting and polishing of those diamonds that are sufficiently perfect for the purpose. Such minute and imperfect diamonds sell at a very low price. I was once offered my choice out of a large cargo, at the rate of three shillings each. Those diamonds which weigh a carat or more, and which are transparent and free from flaws, sell at a high price, which increases as the square of the weight. According to Mr. Jeffries, who was a jeweller in London, and published a treatise on diamonds and pearls about the middle of the last century, an unwrought diamond weighing 1 carat, if free from flaws, is worth two pounds sterling. If we multiply the square of the weight (in carats) by two, the product represents the value of the uncut diamond. Thus, the diamond in the Hunterian museum, which weighs 10·825 grains, or 3·518 carats, is worth £24 : 15s.

If the diamond has been cut and polished, he reckons its value when it weighs one carat, to be eight pounds sterling. And the square of the number of carats constituting the weight multiplied by 8, gives the value of polished and cut diamonds in pounds sterling. According to this mode of valuing, the Pitt diamond, which weighs 136¼ carats would be worth 148,512 pounds sterling. But large diamonds are so rare, that they are valued at a much greater price than that which would result from multiplying the square of their weight in carats by 8.[*]

Sp. 2. *Plumbago* or *Graphite.*

This mineral is distinguished in common language by the name of *black lead.* It constitutes the ingredient of which writing pencils are usually made. Plumbago was long confounded with *molybdena:* indeed the two minerals were not accurately distinguished, till Scheele determined the properties of each in 1779.[†]

The colour of plumbago is steel grey, and it has the metallic lustre. The streak is splendent and metallic.

Its hardness is 1, for it is easily scratched by gypsum, but scarcely by talc. It is sectile, has a greasy feel, and writes readily upon paper. The thin laminæ are highly flexible. Opaque.

The specific gravity varies from 2·25 to 2·32.[‡]

Its texture is foliated; though from the occasional small size of the plates, this cannot always be observed. In Greenland, and in the neighbourhood of Philadelphia, it has been met with crystallized in six-sided prisms. But nothing is known respecting the angles of these crystals.[§]

When plumbago is boiled in nitro-muriatic acid, a portion of oxide of iron is dissolved. When mixed with ten times its weight of saltpetre, and heated to redness, it deflagrates with violence, and leaves a brown coloured residue, which varies in different specimens both in quantity and composition; showing that it is merely foreign matter not chemically combined with the plumbago, but simply mixed mechanically with it. In Gahn's and Hjelm's trials, it amounted to ten per cent. and was peroxide of iron or ochre of iron, as Scheele expresses himself.[||] A fine specimen examined by Allen and Pepys, left only 5 per cent.[¶] A specimen from Borrowdale, analyzed by Schräder, left 14·75 per cent. This residue had a brown colour, and was composed of

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[*] Some account of the price of diamonds in India, will be found in Brewster's Journal, vii. 134.

[†] Pliny employs molybdena and plumbago as synonymes for a plant. (Hist. Nat. lib. xxvi. c. 13.) He uses *molybdena* also for *litharge,* and describes it as the same with *galena.*

[‡] Schräder; Annals of Philosophy, i. 299.

[§] Hauy; Traité de Mineralogie, iv. 85; 2d edition.

[||] Scheele's Essays, p. 246.

[¶] Nicholson's Jour. xix. 233.

Protoxide of iron,	5·8
Silica,	3·5
Alumina,	2·3
Oxide of titanium,	3·15
	14·75*

Professor Vanuxem analyzed three specimens of plumbago,† and found their constituents as follows:

Carbon,	88·37	61·27	94·4	62·8
Water,	1·23	5·33	0·6	——
Silica,	5·10	10·10	2·6	21·6
Alumina,	1·00	3·20	0·0	9·3
Lime,	——	——	——	0·2
Oxide of iron and manganese,	3·60	20·00	1·4	5·4
	99·30	99·9	99·0	99·3‡

The first two of these specimens were from Borrowdale, in Cumberland, the third, from Bustletown, Pennsylvania.

If we abstract these foreign bodies, plumbago may be considered as consisting of carbon, seemingly from the experiments of Davy, not quite free from hydrogen.

Plumbago is found usually in primary or transition rocks. At Borrowdale, in Cumberland, which yields the finest plumbago known, it occurs in nests in a greenstone rock, which constitutes a bed in clay slate, together with felspar porphyry, and hornstone porphyry. In Glenstrathfarrar, in Inverness-shire, it constitutes nests in gneiss. At Arendal, in Norway, it is found in a quartz rock. In the United States of America, it is met with in various rocks, but all primary; sometimes in granular foliated limestone, sometimes in felspar, and sometimes in mica slate.

A mineral resembling plumbago, and applied to many similar purposes, is found in Ayrshire in the coal beds. There is a mine of it about four miles from New Cumnock, belonging to the Marquis of Bute. The plumbago occurs in the sixth bed from the surface, the bed immediately above and immediately below, consists of greenstone. The plumbago is mixed with anthracite or glance coal, and constitutes a bed from 3 to 6 feet thick. It is occasionally mixed with greenstone.

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* Annals of Philosophy, i. 209.

† Ibid. (2d series) ii. 107.

‡ This column gives the constituents of Ceylon graphite, as analyzed by Princep. Ann. des Mines, (3d series) v. 523.

Another mine of plumbago exists on the banks of the Ayr river, about 8 miles east from the town of Ayr, near the place where the celebrated hones, known by the name of *water of Ayr stones* are found. The plumbago in this mine, however, is far from being pure, and indeed is rather entitled to the name of *anthracite* than of *plumbago.* It is not fit for pencils, but is used in the manufactory of black-lead crucibles, for polishing cast iron grates, and to obviate friction.

Sp. 3. *Anthracite.*

Glance coal and Columnar coal of Werner, Kilkenny coal, Blind coal, Culm.

This is a species of coal distinguished from common coal by its higher specific gravity, its semimetallic lustre, and by its burning without emitting smoke; though, when it contains moisture, (as is frequently the case) it emits a low yellow flame.

The colour is black; the lustre splendent and semimetallic. Sometimes beautifully iridescent. It is opaque, and breaks usually with a conchoidal fracture. Hardness about 2. In general it is rather harder than common coal; though this is not always the case.

Specific gravity of the Pennsylvania coal, which belongs to this species, from 1·52 to 1·55; that of Rhode island 1·75.* I found that of Kilkenny coal 1·4354. Mohs states the specific gravity of the columnar coal from Meissner, to be 1.400, and that of the glance coal from Schönfield, in Saxony, 1·482.

I have never seen it under any regular form. But Hauy states that it has been met with in the coal mines of Berg, on the right banks of the Rhine, in imperfect acute octahedrons. He considers the primary form to be that of the regular six-sided prism.

By friction when insulated, it acquires negative electricity.

Anthracite when pure consists almost entirely of carbon, in that black state in which it exists in charcoal. Kilkenny coal leaves, when burnt, 4 per cent. of ashes. Two varieties of anthracite, that of Lehigh, in Pennsylvania, and that of Rhode island, were analyzed by Mr. Vanuxem,* who found the constituents as follows:

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* Silliman's *Jour.* x. 333.

	Lehigh coal.	Rhode island coal.
Carbon, ...	90·1	90·03
Water, ...	6·6	4·90
Silica, ...	1·2	2·14
Alumina, ...	1·1	——
Oxides of iron and manganese,	0·2	2·50
	99·2	99·57

Anthracite occurs occasionally in primary rocks. Thus Ramond found specimens of it in gneiss, on the table land of Troumou in the upper Pyrenees. It is much more abundant in transition rocks. The Lehigh coal in Pennsylvania, extends in length 100 miles, partly along the Susquehannah river, till it is lost at Peter's mountain, a few miles above Harrisburgh. The mean thickness of this bed of anthracite, is from 12 to 15 feet, though in some places it amounts to from 30 to 40 feet. It alternates with clay slate, mica slate, and a micaceous sandstone.† And Mr. Maclure informs us, that the whole of that part of the country is transition.‡ A very extensive tract of anthracite occurs also in Rhode island. This coal has of late years been brought into common use in America. Anthracite occurs also in the common coal measures. This is probably the case with the Kilkenny coal in Ireland. It is certainly the case with the Welsh *culm*, so extensively used in the iron works in South Wales. Many other localities of it in the common coal beds might be pointed out, both in Great Britain and on the continent.

Sp. 4. *Bituminous Mineral Coal.*

Brown coal, black coal, slate coal, moorcoal, jet, &c.

This very important mineral occurs in the earth, in beds usually alternating with slate clay and sandstone, and is employed very abundantly in this country as an article of fuel. A great number of different kinds have been described, but it will be sufficient if we notice the following sub-species, which constitute the common varieties in this country.

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* Annals of Philosophy, (2d series) xi. 105.

† See a description by Mr. Cist in Silliman's Jour. iv. 1.

‡ Ibid.

I. *Caking Coal.*

When this coal is heated, it breaks into a great number of small pieces. When the heat is raised to a certain point the coal melts, and all the fragments become united together in one solid mass. It is to this property that the name of *caking coal* is owing.

The colour is velvet black, or in some places greyish black. Lustre shining, resinous. The principal fracture is straight, slaty; the cross fracture partly small grained uneven, when the lustre is only *glistening;* partly small conchoidal, when the lustre is *shining.* It is not uncommon to find in it thin seams, exactly similar to wood charcoal.

It is soft, and very easily frangible. The fragments have more or less of a cubic shape. Soils the fingers; specific gravity 1·269. It catches fire very readily, and burns with a lively yellow flame; but in consequence of its caking property it requires to be frequently stirred to admit the free ingress of air, otherwise it is extinguished. It is a lasting coal, and gives out much heat; but it requires care to manage it well in a common fire.

The best Newcastle caking coal contains $1\frac{1}{2}$ per cent. of earthy matter. The combustible portion is a compound of carbon, hydrogen, azote and oxygen, in the following proportions:

33 atoms carbon, = 24·75
11 atoms hydrogen, = 1·375
3 atoms azote, = 5·25
$1\frac{1}{2}$ atoms oxygen, = 1·5

32·875*

The principal beds in the Newcastle coal field consist of this kind of coal. It constitutes the sixth bed (reckoning from the surface) of the Glasgow coal field. The coal at Hurlet, about 5 miles south-west from Glasgow, is a caking coal. It occurs also at Bannockburn, and in various places in Fifeshire.

II. *Splint Coal.*

This coal constitutes the fifth of the Glasgow beds, or the lowest bed at present wrought.

It is thin, varying from thirty inches to three feet. It occurs also occasionally in the other Glasgow beds, particularly the second. It is the most valuable of the Glasgow coal, and always sells at a higher price than the *cherry* or *soft coal.*[*]

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* Annals of Philosophy, xiv. 91.

The colour is black, with a slight shade of brown. The lustre is between glimmering and glistening; resinous; lustre of the streak between glistening and shining. Thin layers of cherry coal often pervade splint coal; they are easily distinguished by their superior lustre.

The principal fracture is imperfect, curve slaty; cross fracture fine grained uneven and splintery.

Soft, but difficultly frangible; much more so than any other species of coal. Hence the reason why the term *hard coal* is often applied to it. The specific gravity is 1·290.

It requires more heat to kindle it than either caking or cherry coal; but when once thoroughly lighted it constitutes a lasting and clear fire, which gives out much heat.

The best splint coal which I have met with contains about 9·5 per cent. of earthy matter. The combustible portion is a compound of carbon, hydrogen, azote and oxygen, in the following proportions:

28 atoms carbon,	21·00
14 atoms hydrogen,	1·75
1 atom azote,	1·75
3½ atoms oxygen,	3·5
	28·00[†]

III. *Cherry Coal.*

This constitutes the greater part of the four uppermost Glasgow coal beds, especially the third and fourth beds. The Staffordshire coal seems to be similar in its nature.

Colour velvet black, with a slight intermixture of grey; the lustre is sometimes splendent, sometimes shining. When the lustre is shining, the coal has exactly the appearance of caking coal; but is easily distinguished as it wants the property of softening and caking when heated. The lustre is resinous.

Principal fracture straight, slaty. The different slates or plates differ in their lustre; some of them are splendent, others only shining. The surface is smooth; when the lustre is splendent the surface is specular, but when only shining, the surface is merely even. Cross fracture usually flat conchoidal and specular splendent. In some places it has occasionally the aspect of wood charcoal.

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[*] The difference is about one shilling per waggon, of 24 Cwt.

[†] Annals of Philosophy, xiv. 92.

Its hardness is about the same as that of caking and splint coal. But it is very easily frangible. Hence there is a good deal of waste in mining it, and as it does not cake, the fragments can be used only for furnaces. Near Birmingham, the loss in mining, including the pillars, amounts to two-thirds of the whole.

The fragments are rectangular, and approach the cubic form. The specific gravity is 1.265.

When exposed to heat it readily catches fire, and burns with a clear yellow flame, giving out a great deal of heat. It burns away much faster than either caking or splint coal.

When burnt it leaves about ten per cent. of ashes. The combustible portion is a compound of carbon, hydrogen, azote, and oxygen in the following proportions:

34 atoms carbon, = 25·5
84 atoms hydrogen, = 4·25
2 atoms azote, = 3·5
1 atom oxygen, = 1·0

34·25*

As this is the most beautiful, it is at the same time the most abundant species of mineral coal. It has got the name *cherry*, from the colliers, in consequence of its lustre and beauty.

IV. *Cannel Coal.*

This species of coal is said to have got its name because when kindled it burns with a clear flame, like a candle. It abounds at Lesmahago, about twenty miles from Glasgow. It is found in different parts of Ayrshire, where it is made into inkhorns, snuff boxes, and other similar ornaments. It abounds, as is well known, at Wigan, in Lancashire; there is a mine of it in Lord Anglesea's park at Beaudesert near Coventry. What is called *jet*, is merely a variety of cannel coal.

The colour is dark greyish black, sometimes brownish black; the lustre is glistening, resinous; it takes a good polish; the fracture is usually large and flat conchoidal. In the great this kind of coal is frequently slaty.

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[*] Annals of Philosophy, xiv. 93.

In some varieties the fragments approach the cubic shape, in others they are wedge-shaped, or even quite irregular.

Soft; sectile; does not soil the fingers; rather difficultly frangible; specific gravity 1·272.

When applied to the flame of a candle it catches fire and burns with a clear yellow flame, without melting. On this account it is frequently employed to give light, as a substitute for candles. If a large piece be put on the fire, it splits into foliæ, and if the flat side of these foliæ be laid over the fire, the pieces fly off with a crackling noise, and are, many of them, driven to a considerable distance. Hence the reason why the term *parrot* coal is applied to this variety in Scotland.

This coal at an average contains about 11 per cent. of earthy matter. The combustible portion is composed of carbon, hydrogen, and azote, in the following proportions:

11 atoms carbon, = 8·25
22 atoms hydrogen, = 2·75
1 atom azote, = 1·75

12·75*

v. *Wood Coal.*

As a variety of mineral coal, we ought to mention *wood coal*, or *brown coal*, as it has been termed by Werner, which occurs usually in the newest formations; it has all the appearance of wood, and obviously consists of trees that have been softened, probably by moisture, and then squeezed flat by pressure. The deposite at Bovey, in Devonshire, constitutes one of the best examples of this kind of coal. Its colour is brown or grey, differing a good deal in the shade; the texture of the wood is preserved, and it burns exactly as wood does; so that there cannot be the least doubt about its origin. Indeed, the common opinion is, that mineral coal in general owes its origin to vegetable matter; but the occurrence of anthracite in primary rocks constitutes a difficulty in the adoption of this theory in every other respect so plausible.

Sp. 5. *Asphalt.*

Black mineral resin of Mohs; bitumen, petroleum, naphtha, &c.

This substance occurs in considerable quantity on the shores of the Dead Sea, and on the surface of a lake in Trinidad. There is a thick bed of it in Albania, from which the Greek fire, so celebrated in the middle ages, was principally formed.

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* Annals of Philosophy, xiv. 94.

When solid, it has a black colour, but is frequently also brownish and reddish. The streak is usually unchanged; but sometimes lighter than the colour of the asphalt.

Hardness, 2. Friable; sectile; lustre resinous; fracture conchoidal, more or less perfect. The specific gravity varies from 1·073 to 1·160. Klaproth states it as high as 1·205.

When heated it melts, gives out a bituminous smell, and colourless naphtha may be distilled from it. Neither acids nor alkalies are capable of acting on it; but it dissolves in naphtha, and in the fixed and volatile oils.

Naphtha, which issues occasionally from the earth in various countries, especially Persia, is a colourless transparent liquid, very volatile, and about $\frac{3}{4}$ths of the weight of water. It is very combustible, and appears to be a compound of carbon and hydrogen in equal atoms, seemingly six atoms of each. When naphtha is exposed to the air, its colour deepens, and its consistency increases, and it gradually assumes the form of *petroleum*, a brown bituminous oily looking matter, which occasionally floats on the surface of springs issuing from coal beds. When the petroleum is heated, it gives out naphtha, and leaves a quantity of asphalt. Pit coal, when distilled, yields also naphtha. Hence naphtha seems to be the part of a series of substances which graduate into each other, and the last of the series is pit coal.*

Sp. 6. *Elastic Bitumen.*

Mineral caoutchouc of Kirwan.

This mineral was first discovered in the forsaken lead mine of Odin, which is situated near the base of Mamtor, to the north of Castletown, in Derbyshire. It was first noticed by Dr. Lister, in 1673.† He called it a subterraneous fungus, and is uncertain whether it belongs to the vegetable or mineral kingdom. It was first accurately described by Mr. Hatchett.‡ In 1816, it was discovered by M. Olivier of Angers, in the coal mine of Montrelais, at the depth of 230 feet. Hausmann states that it has been observed also at Neufchatel, and in the island of Zante.*

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* From the late experiments of Reichenbach, naphtha appears to be a very complex substance; and Dr. Christison and Dr. Gregory have shown that two distinct species of natural naphtha occur.

† Phil. Trans. viii. p. 6179.

‡ Linnæan Trans. iv. 146.

Its colour is blackish brown of various shades.

Internally it is shining and glistening; lustre resinous; fracture conchoidal; translucent on the edges; very soft; sectile; soft and elastic, flexible. The specific gravity of the Derbyshire variety, as determined by Hatchett, varies from 0·9053 to 1·233; that of the French is lighter than water.

It catches fire readily, and burns with a lively yellow flame, giving out a bituminous odour. The English and French varieties were subjected to analysis by M. Henry, junior.† The results were as follows:—

	English variety.	French variety.
Carbon,	0·5225	0·5826
Hydrogen,	0·0746	0·0489
Azote,	0·0015	0·0010
Oxygen,	0·4011	0·3675
	1·0000	1·0000

This corresponds with

35 atoms carbon, = 26·25
3 atoms hydrogen, = 0·375
2 atoms oxygen, = 2·000

28·625

for the English variety; and

41 Carbon, = 30·75
2 Hydrogen, = 0·25
2 Oxygen, = 2·00

33

for the French variety.

It is obvious that these numbers can be considered only as rude approximations to the truth.

Sp. 7. *Retinasphaltum.*

This mineral was first observed accompanying Bovey coal in Devons[illegible] was noticed by Dr. Milles.‡ Its nature was af[illegible]ccurately determined by Mr. Hatchett.§ It w[illegible] by M. Voight in a bed of bituminous vegetable earth near Helbra, in the county of Mansfield;[*] and soon after it was discovered in the neighbourhood of Halle, in a bed of brown coal, and subjected to a chemical examination by Bucholz.[†]

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† Ann. des Mines, xii. 269.

[illegible]04, p. 401.

The colour is pale brown ochraceous yellow. The fracture is imperfectly conchoidal. It appears earthy externally; but when broken exhibits a slight resinous lustre; very soft and easily frangible. It is usually, when first dug up, elastic flexible; but loses this property on exposure to the air.

Its specific gravity, as determined by Hatchett, was 1·135. The variety described by Voight is said to be very light, sometimes even swimming in water. Bucholz states the specific gravity of the retinasphalt found near Halle, to be nearly the same as that stated by Hatchett.

When heated it melts, smokes much, and burns with a bright flame, giving out a fragrant odour. The melted mass, when cold, is black, very brittle, and breaks with a glossy fracture. The Bovey retinasphalt, according to the analysis of Hatchett, is composed of

Resin, . . .	55
Asphalt, . . .	41
Earthy matter, . .	3
	99[‡]

According to Bucholz, the retinasphalt from Halle is composed of

Resin soluble in alcohol, .	91
Resin insoluble in alcohol, .	9
	100[§]

Sp. 8. *Scheererite.*[||]

Prismatic resinous naphthaline of Koenlein.

This substance was observed in the year 1822, in the beds of brown coal at Uznach in Switzerland. These beds are from 2 to 6 feet thick, and belong to a very recent formation.[¶]

The colour of the mineral is white, or sometimes greenish or yellowish, like talc. It has the form of small needle-shaped crystals, and is deposited in hollows in the brown coal; lustre resinous.

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[*] Jour des Mines, xv. 77.

[†] Schweigger's Jour. i. 290.

[‡] Phil. Trans. 1804, p. 404.

[§] Schweigger's Jour. i. 293.

[||] This name was given by Stromeyer, from M. Scheerer, who, it seems, first observed the mineral.

[¶] Poggendorf's Annalen der Physick, xii. 336.

Soft; translucent; very easily frangible; without taste or smell, even when rubbed.

Specific gravity, according to Macaire Princep, 0·65, that of water being 1.

Stains paper like oil.

It melts, according to Macaire Princep, when heated to 111°, and boils at the temperature of 197½°.

It dissolves very slowly in alcohol; ether is a better solvent, and so is warm oil of turpentine. It does not combine with alkalies. It dissolves slowly in dilute sulphuric acid, and communicates a red colour to the liquid. When heat is applied, the solution becomes first brown and then black, and charcoal is at last deposited. It is soluble in the fat oils.

Catches fire easily, and burns with a pale flame, giving out much smoke.

According to the analysis of M. Macaire Princep, it is composed of

$$\left.\begin{array}{lll}\text{Carbon,} & 73, & \text{or 1 atom}\\ \text{Hydrogen,} & 24, & \text{or 2 atoms}\end{array}\right\}\text{ nearly.}^*$$

It is obvious from its properties and constitution that Scheererite is quite a different substance from naphthaline.

Sp. 9. *Mineral Tallow.*

Hatchettine of Conybeare—Bergfet.

This substance is noticed by Mr. Kirwan in his Mineralogy (vol. ii. p. 47,) but it has not found a place in modern systems of mineralogy.†

It was first found by some peasants on the coast of Finland, in the year 1736. Afterwards a similar substance occurred in one of the Swedish lakes, and M. Hermann, a physician in Strasburg, discovered a similar substance in the water of a fountain near that city. There is a fine specimen of it in the Hunterian Museum at Glasgow, which was found near Inverary, in the County of Argyle. I have another specimen in my possession, which was found in a moss near Oban, in the same county. The Hatchettine of Conybeare seems to

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[*] Poggendorf's Annalen der Physick, xv. 294.

[†] Phillips indeed gives an account of it under the name of *Hatchettine Mineralogy*, p. 374. Magellan also notices it from Kirwan, in his English edition of Cronstedt's Mineralogy.

be a variety of the same substance. It was found by him in 1820, in the ironstone of Merthyr Tydvil, in South Wales.*

It is white, and has nearly the consistency of spermaceti; but does not exhibit any appearance of crystallization; soft; fracture even; tasteless; lustre resinous or waxy. It melts when heated to 118°, and boils at 290°.

Its specific gravity is not easily determined, because it is difficult to free it from air. After standing under the vacuum of an air pump for 24 hours, the specific gravity was 0·8035. After fusion the specific gravity was 0·983. This I consider as the true gravity, because by fusion the air bubbles were expelled, and the cavities in it filled up. It is partly but not completely soluble in alcohol. It does not form a soap, nor combine with soda.

The Hatchettine is not quite so firm as the mountain tallow. Its colour is greenish yellow, the texture is slightly flaky, and it is not opaque as mountain tallow is, but slightly translucent. It melts according to Conybeare at 170°, and is lighter than water. In its chemical properties it agrees with mountain tallow.

The analogy between mountain tallow and Scheererite, is very considerable. Probably they will ultimately be found only varieties of the same substance.

Sp. 10. *Amber.*

This mineral has been known since the commencement of history, and was employed by the ancients as a medicine, and worn by them as an ornament. Theophrastus, who lived three hundred years before the Christian era, mentions it as a stony body, by which probably he meant, that like stones it was dug out of the earth.

Amber is cast ashore on the north coast of Germany, from the Baltic, and on the east coast of England, from the German ocean. It is dug up in considerable quantities in North Prussia, from which the great supply of amber comes. It is found there in beds of bituminous wood, from which it is disengaged by the action of the waves, and in the mines it is deposited in considerable quantity below the bituminous wood. It has been observed, also, in a similar position in Sicily, Spain, France, Greenland, China, &c.

Insects and other organic bodies are frequently found engaged in it. From this, it has been concluded, that it was originally exuded from trees in a liquid state, and that it gradually became solid by exposure to the air.

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* Annals of Philosophy, (2d series,) i. 136.

It occurs in irregular forms, grains and spheroidal masses; fracture conchoidal; surface uneven and rough. It has never been observed in crystals.

Its colour is yellow, passing into red, brown, and white, streak white; often transparent, sometimes only translucent.

Hardness 2 or 2·5. Specific gravity of yellow amber as determined by Mohs 1·081.

When rubbed, it becomes negatively electric. When rubbed, pounded, or burnt, it gives out an agreeable odour.

When heated, it swells and burns; when distilled, it yields *succinic acid.*

Amber is capable of being turned on the lathe and polished. It then possesses great beauty, and is occasionally employed as an ornament.

It contains at least five different substances, namely, 1., a volatile oil, to which it owes its aromatic smell. It exists in small quantity. Doubtless it was originally abundant, and gave fluidity to the amber. 2. A yellow resin easily soluble in alcohol, ether, and alkalies. 3. A resin soluble in hot alcohol, and precipitating in a white powder as the solution cools. 4. Succinic acid. 5. A substance insoluble in alcohol, ether, and alkalies, similar to a substance found in lac.

Sp. 11. *Highgate resin.*

Fossil copal of Aiken.

This mineral was discovered about the year 1812, during an attempt to pass a tunnel through Highgate Hill, on the north side of London. It was in small pieces without any regular shape. The colour was muddy yellowish brown; semitransparent; lustre resinous; brittle; hardness 2·5; specific gravity 1·046.

When heated it melts into a limpid fluid, and gives out a resinous and aromatic odour. Takes fire at the flame of a candle, and burns all away without leaving any residue. Insoluble in potash ley and acetic acid. Soluble in ether, and partially in alcohol.

Genus II. BORON.

Boron, which constitutes the base of boracic acid, is a black substance, somewhat like charcoal, which has never been met with in the mineral kingdom. But the combination of boron and oxygen, known by the name of boracic acid, occurs in that kingdom, and constitutes the only species belonging to this genus at present known.

Sp. 1. *Boracic Acid.*

Sassolin of Reuss.

This acid is rare in the mineral kingdom. It has been observed in the craters of certain volcanoes, particularly in that of Vulcano, one of the Lipari islands, where it was first observed by Mr. Smithson Tennant, and afterwards by Dr. Holland. It was first observed as a deposit from the hot springs at Sasso, a city in Sienna, Italy.* It exists also abundantly in the Lagoni, in Tuscany, and considerable quantities of it are imported into this country to be converted into borax for the use of the potteries.

The boracic acid from Vulcano is in small scales, translucent, having a pearly lustre, and a white colour, except when tinged yellow by an accidental mixture of sulphur.

It is very light, and the scales adhere to the fingers. Its taste is slightly saline, and it is soluble in water, by which it may be separated from all admixture of sulphur. The proportion of sulphur, as Stromeyer has shown, varies from 5 to 20 per cent., proving that it is not chemically combined, but only mechanically mixed.

When put into the flame of a candle, it at first tinges it green; but when the water of crystallization is completely dissipated the green tinge disappears. Stromeyer has shown that this boracic acid is pure, and that it retains its water of crystallization.†

The variety called *sassolin* occurs in stalactites having a white colour, here and there spotted with Isabella yellow. It has a smooth and soapy feel, and is composed of small scales.

Vulcanic boracic acid is pure, if we except the occasional admixture of sulphur. Sassolin was found by Klaproth to contain the following substances:—

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* Hence the name *Sassolin*.

† Untersuchungen, p. 280.

Hydrous boracic acid, . . .	81·33
Sulphate of manganese with some iron,	10·50
Sulphate of lime, . . .	2·83
Silica, ...	2·66
Carbonate of lime, . . .	1·66
Alumina, ...	0·66
Peroxide of iron, . . .	0·33
	99·97*

The foreign bodies are obviously mechanical mixtures.

Boracic acid is very seldom found in the mineral kingdom combined with bases. Only three species containing it are at present known to exist. These are,

1. Borax or biborate of soda.
2. Boracite, or biborate of magnesia.
3. Tourmalin, which contains biborate of lithia combined with two silicates.

Genus III. SILICON.

Silicon, which constitutes the base of silica, has never yet been met with in the mineral kingdom, but the combination of it with oxygen, called *silica*, is exceedingly abundant, and presents itself under so many forms, that it has been subdivided into no fewer than eight different species. Of these we shall now give a description.

Sp. 1. *Quartz.*

Rock crystal, amethyst, cantalite, dragonite, iron flint, prase, rose quartz, milk quartz, siderite.

Quartz constitutes one of the most abundant of minerals, being one of the constituents of granite, gneiss, mica slate, and sandstone.

Its colour when pure, is white; but it is often coloured *violet*, when it is called *amethyst; red*, when it is called *rose quartz; green*, when it is called *prase; yellowish green*, when it is called *cantalite; yellow*, when it is called *Indian topaz*, or *cairngorum stone.* It occurs, also, *blue*, when it is called siderite; *smoke-grey*, *brown*, and *black*, or *blackish brown.* When transparent and colourless, it is called *rock crystal.*

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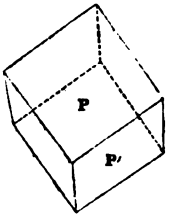
* Beitrage, iii. 97.

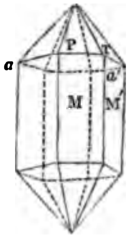
The fracture is small conchoidal. Cleavages may be discovered parallel to the faces of a triangular dodecahedron, composed of two six-sided pyramids applied base to base; but quartz cannot be said to have a foliated structure.

It occurs very frequently crystallized, and the most common form is a six-sided prism terminated by six-sided pyramids. The primary form is a rhombohedron deviating but a few degrees from a cube.



P on P′ 94° 15′

This primary form is sometimes met with; but by far the most common form is a regular six-sided prism terminated by six-sided pyramids.



M on M′ 120°.
M on P 141° 40′.
P on T 133° 48′.

When the intervening prism is wanting, the crystal becomes a dodecahedron composed of two six-sided pyramids applied base to base. The two adjacent faces of each pyramid are inclined to each other at angles 76° 40′.

Sometimes the angles *a*, a′ are replaced by small rhombs. Sometimes the face M is much broader than the two contiguous faces of the prism M′. Sometimes all the edges of the pyramids are replaced by tangent planes. The relative size of the faces varies exceedingly.

Lustre splendent and vitreous in the crystallized specimens. Sometimes the lustre inclines to resinous. Sometimes it is only shining or glimmering.

Crystals often transparent, sometimes only translucent. The amorphous specimens sometimes opaque, or only translucent on the edges.

Refracts doubly.

Hardness 7. Specific gravity of a snow-white crystal 2·690.* Hauy gives the specific gravity 2·6701.† According to Brisson, it is 2·654. Beudant found the specific gravity to vary from 2·6413 to 2·6541.‡

Before the blowpipe it undergoes no change per se; but with carbonate of soda, it fuses with brisk effervescence into a transparent glass.

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* Mohs, ii. 334. † Hauy, ii. 229.

‡ Ann. *des Mines (2d series)*, v. 275.

When pure, it is composed of nothing but silica. Traces of alumina, oxide of iron, or oxide of manganese, are found often in apparently pure specimens.

Quartz crystals occur most commonly in cavities in granite. The finest specimens are found in Dauphiné, the Alps of Saltzburg, the Tyrol, Switzerland, Piedmont, and Savoy. They occur, also, in the islands of Madagascar and Ceylon. The cairngorum pebbles are found near the source of the Dee, at the head of Aberdeenshire, in the highest mountainous tract in Scotland. But deeper yellow, and more beautiful transparent specimens of rock crystal are brought from Brazil. Rose quartz occurs at Rabenstein, near Zwiesel, in Bavaria and in Siberia. It is found, also, in the United States of America. The milk-white varieties are from Norway, Spain, France, &c.

What is called *prase*, is quartz tinged green by *epidote*. It occurs at Breitenbrunn, in the mining district of Schwartzenburgh, in Saxony.

Sp. 2. *Kilpatrick Quartz.*

In the amygdaloid, which constitutes a considerable portion of the Kilpatrick hills, terminating near Dumbarton on the north side of the Clyde, a kind of quartz occurs, which seems entitled to rank as a separate species.

It is white and translucent, and constitutes spheres about the size of a hazel nut, mixed abundantly with stilbite and calcareous spar. I have not seen it in situ, but it seems from its appearance to occur in cavities, or rifts in the rock.

These spheres constitute an aggregation of crystals, the forms of which cannot be made out, but the exterior termination of each, when examined under a microscope, appears to be a four-sided pyramid. So that each of the spheres is studded with small microscopic four-sided pyramids.

The hardness is 7, the same as that of rock crystal. But the specific gravity is only 2·525.

Its constituents were found to be

Silica, . .	96·2
Water, . .	3·0
	99·2

The water contained traces of sulphuric acid.

This constitutes very nearly

18 atoms silica, . .	36
1 atom water, . .	1·125
	37·125

The presence of water, the smaller specific gravity, and the different shape of the crystals, seem to warrant the propriety of constituting this kind of quartz into a peculiar species.

Sp. 3. *Calcedony.*

Bloodstone, carnelian, Egyptian pebble, heliotrope, sardonyx, onyx, mocha stone, haytorite.

Calcedony seems to bear the same relation to rock crystal that common stalactite does to calcareous spar. It occurs most commonly in the cavities of amygdaloidal rocks; though sometimes, also, it constitutes veins.

Its colour is most commonly grey, of various shades and degrees of intensity. Blue, green, brown, and yellow, are not uncommon colours. It is also said to have been observed of a brownish black colour. In some of the varieties various colours appear together either in stripes or spots. Sometimes thin layers of different colours alternate with each other.

The fracture is even and fine grained. In some cases a fibrous fracture may be perceived.

Most commonly calcedony is amorphous; but it is sometimes found crystallized in small rhombohedrons, having the same angles as the primary crystal of quartz. This shows that the difference between calcedony and quartz lies merely in the way in which the particles have been united together. Those of calcedony have been deposited from a liquid, and have in general solidified too rapidly to assume a regular form, while quartz has always crystallized either regularly or irregularly. The variety called Haytorite, exhibits pseudomorphous crystals, which Mr. Levy has shown to be analogous to those of Humboldtite, a mineral which is probably a variety of datholite.*

The lustre is dull, or only glimmering. The hardness is the same as that of quartz.

It is generally semitransparent, or at least translucent. The lightest kinds more, and the darkest less so. Some of the deepest coloured specimens are only slightly translucent.

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* Phil. Mag. *(2d series), i. 38. Phillips'* Mineralogy, p. 379.

I found the specific gravity of a very pure specimen 2·600. Two specimens were found by Hoffman, the first 2·583, the second 2·620.* According to Brisson, the specific gravity varies from 2·583 to 2·664.

Before the blowpipe, it behaves exactly as quartz does.

Calcedony, when pure, consists of silica with a small quantity of water, which seems not enough to be chemically combined. For example, Wöhler found Haytorite composed of

Silica, . .	98·5
Peroxide of iron, .	0·2
Water, . .	0·5
	99·2†

If the water in this specimen be chemically combined, it would be a compound of

114 atoms silica, .	228
1 atom water, .	1·125
	229·125

Now this, to say the least of it, is rather an improbable combination.

The term *calcedony* is generally applied by dealers to the grey-coloured varieties. Those that have a red colour, are called *carnelian.*

Alternate layers of brown and opaque white calcedony constitute the *onyx.* When the colour is a deep brownish red, or by transmitted light blood-red, the stone is termed *sard.* Alternate layers of sard and milk-white calcedony constitute *sardonyx.*

Plasma has a dullish green colour with yellow and whitish dots, and a glistening lustre. It has not been analyzed; but is considered at present as a variety of calcedony.

Heliotrope has a deep green colour, and blood-red spots are ientrspersed through it. From this latter circumstance it has got the name of *bloodstone.*

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* Handbuch, ii. 111.

† Poggendorf's Annalen, xii. 136. I found a calcedony constituting sphericles in a felspar porphyry from the Morne mountains, Ireland, having a specific gravity of 2·641 composed of

Silica, ...	95·15
Alumina, with a little peroxide of iron, .	1·95
Lime, ...	2·25
Water, ...	1
	100·35

Chrysoprase has an apple-green colour, and in other respects approaches calcedony. Its specific gravity is stated in some mineralogical systems to be 3.25, on the authority of Klaproth. But Klaproth, in the paper in which he relates his analysis of chrysoprase, says nothing about its specific gravity.* Hoffmann found the specific gravity to be 2·608.† It contains 96·16 per cent. of silica, 1 per cent. of oxide of nickel, with a very little lime, magnesia, alumina, and oxide of iron.‡

Mocha stone is calcedony, containing dendrites, usually of a black or brown colour; but sometimes green, and bearing considerable resemblance to certain mosses.

Agate is a compound mineral, consisting of alternate layers of calcedony and quartz, jasper, heliotrope, or opal. Calcedony is usually the basis. The crystals of quartz, or amethyst, which it contains, are commonly in the centre; showing, when it occurs, that it has been formed by depositions of siliceous matter within the cavity. After the first layers of calcedony have been deposited, the silica in the fluid still remaining in the central portion shoots into quartz crystals, which are more or less regular.

Sp. 4. *Flint.*

Pyromachus, pierre à fusil, feuerstein.

This mineral occurs in great abundance in common chalk, in which it is deposited in tuberose masses, and in pretty regular layers, each in an insulated state. It is found also occasionally in amygdaloid, being sometimes a constituent of agate. It is said also to occur in veins both in primary and transition rocks.

The colour is usually grey, of various shades and degrees of intensity. Black, brown, yellow, and red, are the colours intermixed with grey in this mineral.

Its fracture is perfect and large conchoidal. It is never crystallized. But when cavities occur in it, they are sometimes lined with small quartz crystals having the usual form.

Lustre glistening or glimmering.

It is translucent; the blackish varieties only on the edges.

Hardness 7, or even 7·25. It is very fragile; being exceedingly easily broken by a blow.

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* Beitrage, ii. 127. † Handbuch, ii. 99. ‡ Klaproth, Ibid.

Its specific gravity, as determined by Hoffman, is from 2.575 to 2·594.[*]

When two pieces of flint are rubbed against each other in the dark, a good deal of light is given out with a peculiar smell. It breaks into wedge-shaped fragments. It gives abundant sparks with steel, and therefore is commonly fixed on musket locks, to kindle gunpowder by striking against the pan of the piece.

Before the blowpipe it behaves like quartz.

It is essentially composed of silica, with a little combined water. A specimen analyzed by Klaproth contained

Silica, . .	98·0
Alumina, . .	0·25
Oxide of iron, .	0·25
Water, . .	1·5
	100[*]

If we admit the alumina and oxide of iron to be accidental ingredients, flint will be a compound of

37 atoms silica, . .	74
1 atom water, . .	1·125
	75·125

Sp. 5. *Opal.*

Cacholong, gyrasol, hydrophane, semiopal, wood opal, opal jasper.

The term *opal* is usually applied to minerals having a certain degree of transparency, but rendered somewhat opaque by a different colour floating, as it were, within the stone. This colour is usually milk-white, constituting what is called the *common opal.* But it is yellow, brown, red, and even green, of different shades. What is called the *precious opal,* is also most commonly milk white; but when held in a proper direction with respect to the light, it displays a beautiful play of colours, blue, green, yellow, and red. Most commonly several of them appear together. When the play of colours exhibits only the red, the stone is called *fire* opal; when the texture is fibrous, the mineral is known by the name of *wood* opal.[‡]

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[*] Handbuch, ii. 84.

[†] Beitrage, i. 46.

[‡] The *opalus* of the ancients (see Plinii Hist. Nat. lib. 37. c. 36.) seems the same as our opal.

The fracture of the opal is perfect conchoidal. In what is called *semiopal*, it is flat conchoidal.

None of the varieties of opal have been observed in crystals.

The lustre is splendent and vitreous. In the *mother-of-pearl* opal it is pearly, and in the semiopal, the lustre is resinous and only glistening.

It is most commonly semitransparent or translucent. The *fire* opal is transparent, and the mother-of-pearl opal opaque.

It is rather softer than quartz. Perhaps the hardness may be nearly represented by 6·75.

The specific gravity varies from 2·015 to 2·21.

It is infusible before the blowpipe.

The precious opal has not been analyzed. The common opal, by Klaproth's analysis, is silica, united to 5 per cent. of water, and 1 per cent. of peroxide of iron. Or, considering the iron as accidental, it is a compound of

10 atoms silica,	.	20
1 atom water,	.	1·125
		21·125

Whether the water be really in chemical combination with the silica, is not known; but that it is so is not improbable.

The precious opal is found chiefly at Czscherwenitza, near Kaschau in Upper Hungary, where it occurs in veins in a clay porphyry, considered as having been ejected from a volcano long since extinct. The other sub-species have been found in veins in primary rocks and in amygdaloid, where they are associated with calcedony. It is stated also in books to occur in beds, but no locality is given.

Sp. 6. *Jasper.*

Sinople, ribbon jasper, Egyptian jasper.

This mineral is easily distinguished from the other species of quartz already described, by its opacity and by the darkness of its colours.

It is a hard mineral, having a conchoidal fracture and a pretty deep colour, either brown, yellow, or red. The lustre is inconsiderable, and most commonly resinous. The specific gravity is about 2·6.

The brown-coloured mineral which occurs so abundantly in rolled pebbles in the deserts of Egypt, is called *Egyptian jasper*. When stripes of green, yellow and red, occur on the same mineral, it is called *striped jasper*. The *jasper agate* is reddish white. Several colours generally appear on the same mineral.

Jasper has not been examined by modern chemists; but it seems to consist of silica united to a small quantity of peroxide of iron. If any confidence can be put in Kirwan's analysis of common jasper, it consists of

Silica, . . .	75
Peroxide of iron, . .	13
Alumina, . .	0·5
Lime, . . .	0·2
	88·8[*]

Were we to consider the silica and peroxide of iron to be in the ratios in which they exist in jasper, it would be a compound of 14½ atoms of silica, and 1 atom of peroxide of iron. But the analysis requires repetition.

Jasper occurs in veins in primary and transition rocks. It is found also in nodules, and associated with calcedony in amygdaloid.

Sp. 7. *Basanite.*

Lydian stone, touchstone, flinty slate.

This mineral is usually met with in beds in grey rocks and trap rocks.

Its most common colour is grey; ash grey, smoke grey, and pearl grey, are the most frequent. Sometimes it is bluish grey. Shades of yellow, brown, and red, are not uncommon. Frequently it presents zoned, striped, or undulating delineations. When greyish black or velvet black, it is called *Lydian stone* or *basanite.* The other colours belong to *Flinty slate.*

The fracture of flinty slate is slaty, that of basanite, even.

It never occurs crystallized.

Lustre glimmering. Frequently traversed in various directions by quartz veins, which have a stronger lustre.

Lydian stone is opaque; but flinty slate is translucent on the edges.

Hardness 7. Very tough.

The specific gravity of Lydian stone, according to Hoffmann, is 2·585, and that of flinty slate from 2·613 to 2·644.[†]

This species has not been analyzed, but it is obvious from its characters that it consists chiefly of silica. Humboldt has rendered it probable, that Lydian stone owes its black colour to charcoal.

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[*] So stated by Phillips, Mineralogy, p. 19. I do not know where this analysis was published.

[‡] Handbuch, ii. 77.

Perhaps this substance should rather be considered as a rock than a simple mineral. If so, it should not find a place in the system.

Besides the species above described, there are some other varieties or sub-species of quartz which have been noticed by mineralogists. The most important of these are the following:

HYALITE or *Muller glass*. It occurs at Frankfort on the Maine, lining the cavities of basalt. It has been observed also in America, Italy, and Hungary.

It has a glassy lustre, is brittle but as hard as quartz. Its specific gravity is stated at 2·4. According to Bucholz, it is composed of

Silica, . . .	92
Water, . . .	6·3
Alumina, trace, . .	——
	98·3

This is nearly 8 atoms silica to 1 atom water.

BURR STONE. This mineral occurs in the tertiary formations in the neighbourhood of Paris, and has been long famous for the excellent mill stones which it forms. It is met with also in England. I have a specimen from Holken.

Its colour is yellowish white, its texture compact, its fracture even, and its hardness and its behaviour under the blowpipe is the same as that of quartz. It contains small cavities which are tinged yellow, obviously by iron. Specific gravity 2·511.

For an account of NECTIC QUARTZ we refer to Hauy, Mineralogy, ii. 266. For the *flexible sandstone* of South America, we refer to Jameson's Mineralogy or Hoffmann's Handbuch, ii. 47.

For an account of *gelatinous silica*, we refer to the Annales des Mines, xiii. 321.

For other varieties, Jameson or Phillips may be consulted.

Silica possesses the characters of an acid. It enters into definite combinations with lime, magnesia, alumina, glucina, yttria, cerium, zirconia, thorina, iron, manganese, zinc, and copper. Like all weak acids it unites with bases in several proportions. Hence, the number of silicates in the mineral kingdom is very great, constituting no fewer than 206 different species of minerals. These different species will come under our review when treating of the genera included under the 2d class of our division, namely, *alkaline bases.*

GENUS IV.—PHOSPHORUS.

Phosphorus has so great a disposition to unite with oxygen that it is never found in the mineral kingdom in an isolated state. As it has a strong affinity for the greater number of the metals, we might have expected that metallic phosphurets would occur; but hitherto no such compounds have been observed. Phosphoric acid, in which the phosphorus is united to oxygen, is rather common in the mineral kingdom, never in an isolated state but always in combination with a base. These combinations, called *phosphates*, will be described among the minerals arranged under the 2d class of our arrangement.

The phosphates at present known to exist in the mineral kingdom, amount to about 12. Their names are as follow:

1 Apatite or subsesquiphosphate of lime,
2 Turquois or trisphosphate of alumina,
3 Wavellite or hydrousdiphosphate of alumina,
4 Phosphate of yttria,
5 Diphosphate of iron,
6 Subsesquiphosphate of iron,
7 Phosphate of iron,
8 Huraulite or ferro-phosphate of manganese,
9 Chloro-phosphate of lead,
10 Hydrous diphosphate of copper,
11 Bihydrous diphosphate of copper,
12 Uranite or calcareo-phosphate of uranium,
13 Chalcoliteor cupreo-phosphate of uranium.

GENUS V.—SULPHUR.

Sulphur has not the same strong tendency to unite with oxygen that phosphorus has. Hence, it is found native in considerable abundance. Its disposition to unite with bases is greater than that of phosphorus. Hence it is found in the mineral kingdom united both with acid and alkaline bases. With the former of these it constitutes acids, to which the name of *sulphides* has been given. With the latter it forms alkalies or bases, distinguished by the name of *sulphurets.*

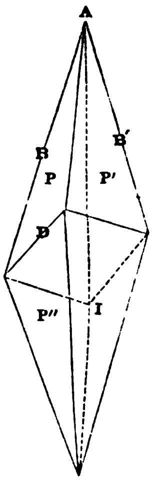
Sulphur is also found in the mineral kingdom united to oxygen, and constituting sulphuric acid. This acid has so great a tendency to unite with bases, that it rarely occurs in an isolated state. Certain lakes in the islands of Java and Borneo are said to be impregnated with this acid in a free state; but no example of this kind has been met with any where else, except in Persia, where there is an earth so strongly impregnated with this acid, that it is used by the natives as an acidulous seasoner of food.

Sp. 1. *Native Sulphur.*

Brimstone.

Sulphur has a greenish yellow colour. The crystals are sometimes transparent, but sometimes only translucent. It refracts doubly so strongly that the image appears double even when viewed through two parallel faces.

The hardness of sulphur is 2·5. Its specific gravity is very nearly 2. Breithaupt found that of a yellow transparent specimen 2·071. Brisson states the specific gravity at 2·033.



The primary form of the crystal of sulphur is an octahedron, composed of two four-sided pyramids, with a rhomboidal base, the dimensions of which are as follow:—

P on P′ 106°20′ according to Brooke.
106 30 according to Phillips.
106 16·5 according to Kupffer.
P on P″ 143°25′ according to Brooke.
143 25 according to Phillips.
143 26·8 according to Kupffer.

Sometimes the face P extends in breadth so as to make the point A assume the form of a wedge. Sometimes the point A is replaced by a small rhomboidal face parallel to the common base of the pyramids. Sometimes the edges D are replaced by tangent planes, introducing an oblique prism between the two pyramids which constitute the octahedron. The angle which P on P″ makes with the adjoining face of the prism is 161° 42′·5.

Sometimes the angle I is replaced by a triangular face, which may also be considered as a tangent plane.

Sometimes the edges B, B′ are replaced by tangent planes. This converts the octahedron into a dodecahedron.

Sometimes the summits A are replaced by low four-sided pyramids.

Mitcherlich has shown that when sulphur is melted and cooled slowly it crystallizes in right rhomboidal prisms. But this form (which is incompatible with the pyramidal) has never been observed in the crystals of sulphur found native.

Sulphur occurs in beds in a blue clay formation, which constitutes a considerable portion of Sicily, occupying the central half of the south coast, and extending inwards two-thirds of the island, and eastward as far as the district of Mount Etna. This blue clay formation, Dr. Daubeny considers as more recent than chalk, and of the same age with the gypsum beds in the neighbourhood of Paris. It contains beds of gypsum and of rock salt. The quantity of sulphur in it must be enormous; for though Sicily has long supplied all Europe with this article, the supply was so far from diminishing that the price for a series of years rather sank than rose. Of late, indeed, there has been a considerable rise, but not owing to any deficiency of the supply, but advantage has been taken of the great increase of demand. The Sicilians purify their sulphur by collecting it in heaps, and setting fire to them on the surface; thus causing the purification of one portion by the combustion of another.*

In veins, sulphur occurs in Suabia, Spain, and Transylvania. It is deposited also from several springs, and in large quantities from volcanoes.

Only two acid combinations of sulphur (exclusive of sulphuric acid) occur in the mineral kingdom; namely,

Sesquisulphide of arsenic, or realgar.

Sesquisulphide of antimony.

And red antimony, in which the sesquisulphide of antimony is combined with deutoxide of antimony.

Fourteen sulphurets occur in the mineral kingdom, in which sulphur is united with an alkaline base. These are

1 Bisulphuret of molybdenum,
2 Sulphuret of iron,
3 Bisulphuret of iron,
4 White sulphuret of iron,
5 Sulphuret of manganese,
6 ———— nickel,
7 ———— lead,
8 Supersulphuret of lead,
9 Cupreous sulphuret of tin,
10 Sulphuret of bismuth,
11 Needle ore of bismuth,
12 Disulphuret of copper,
13 Sulphuret of mercury,
14 ———— silver.

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* Silliman's Jour. x. 242.

There are 17 sulphur salts formed by the combination of sulphides with sulphurets. These are

1 Nickel glance,
2 Sulpho-antimonide of nickel,
3 Sulpho-arsenide of cobalt,
4 Zinkenite,
5 Jamesonite,
6 Feather ore of antimony,
7 Variegated copper ore,
8 Copper pyrites,
9 Bournonite,
10 Grey copper ore,
11 Tennantite,
12 Cupreous sulphide of silver,
13 Silver glance,
14 Dark red silver ore,
15 Light red silver ore,
16 Myargirite,
17 Polybasite.

The sulphates, consisting of combinations of sulphuric acid with one or more bases, amount to 27.

All of these minerals will be described in the subsequent part of this treatise.

GENUS VI.—SELENIUM.

Selenium has not yet been met with in the mineral kingdom in an uncombined state. In the state of selenious or selenic acid it has not yet occurred in any mineral substance; but combined with a base in the state of seleniet, it has been met with, and four such species are known to exist; namely,

1 Seleniet of zinc,
2 Seleniet of lead,
3 Seleniet of copper,
4 Seleniet of silver.

GENUS VII.—TELLURIUM.

This rare metal has hitherto been found only in Transylvania, and in Norway. Various species of tellurium ore have been described, but only one of these belongs to this genus; namely,

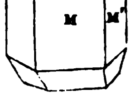
Sp. 1. *Native Tellurium.*

The colour of this mineral is tin-white, and the lustre metallic. It has been found in crystals, which, according to Mr. William Phillips, are regular six-sided prisms. The figure in the margin represents the modification described by Mr. Phillips.

M on M′ 120°.

The edges at the base of the prism are replaced by the faces c, c′.

M on c or M′ *on c′ 147° 36′.*



It is obvious from this that the faces c, c' are not tangent planes, for the inclination of c on the base of the prism is only 122° 24'. These crystals are so small that the cleavage planes have not been ascertained.

This mineral is always opaque; it is brittle; its hardness is 2 to 2·5; its specific gravity, as determined by Mr. W. Phillips, from 5·7 to 6·1.

When exposed to the action of the blowpipe, it melts before ignition, and on the increase of the heat, burns with a bluish green flame, and is almost entirely volatilized in a dense white vapour, having the smell of horseradish.

According to the analysis of Klaproth, it is composed of

Tellurium . .	92·55
Iron . . .	7·20
Gold . . .	0·25
	100·00*

It is possible that this mineral may be a compound of 11 atoms tellurium, and 1 atom iron, but as the ore is mixed with a good deal of stony matter, it is more likely that the iron is only mechanically mixed.

Native tellurium has been hitherto found only in the mine of Maria Loretto at Facebay, near Zalathna, in Transylvania. It is very rare at present; but about 40 years ago it was met with in considerable quantity, and was melted to extract from it the little gold which it contains. It was in a sandstone, but whether in veins or beds is not quite certain.

There are three other species of tellurium ores, in each of which it is united with one or more metallic bases. These are

1 Foliated tellurium ore, or bitelluret of lead,
2 Graphic ore of tellurium, or argento-telluret of gold,
3 White tellurium ore, or plumbargento-telluret of gold.

These will come under our consideration in a subsequent part of this treatise.

GENUS VIII.—ARSENIC.

This poisonous metallic substance occurs pretty frequently in the mineral kingdom. It is found sometimes uncombined in the metallic state, and metallic arsenic is found united with other metallic bodies, constituting *arseniets*. It occurs likewise united with oxygen, constituting both *arsenious* and *arsenic* acids. The former of these is found in the mineral kingdom uncombined, but not the latter. Arsenic acid, however, enters into combination with various alkaline bases, constituting *arseniates*. Arsenic also is found united to sulphur in two different proportions, constituting two sulphur acids, which enter into various chemical combinations in the mineral kingdom. The species belonging to this genus are the five following:

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* Beitrage, iii. 2.

1 Native arsenic,
2 Arsenious acid,
3 Arsenic acid,
4 Sulphide of arsenic,
5 Sesquisulphide of arsenic.

Sp. 1. *Native Arsenic.*

When metals occur in the earth in a state of purity, or nearly so, mineralogists distinguish them by prefixing the epithet *native*. When they are met with in combination with sulphur, or with some other bodies, they are said to be *mineralized*. By *native arsenic* then is meant arsenic in the metallic state, or nearly pure.

Its colour in the fresh fracture is nearly tin-white, but it speedily tarnishes and becomes greyish black.

The lustre is metallic. It occurs massive and in various accidental forms, but has never been observed in regular crystals. When sublimed, arsenic crystallizes in octahedrons, which Romé de Lisle considered as regular; but Hauy doubts whether the fibrous form of arsenic, after fusion, be compatible with that figure.

Hardness about 5; but it becomes softer on exposure to the air. When reduced to powder, it speedily becomes black.

The specific gravity of arsenic, when pure, is 5·672.* Native arsenic usually contains a small portion of some other metal, which increases its specific gravity somewhat. Brisson states it at 5·7249.† Breithaupt found a specimen of Saxon native arsenic as high as 5·923.‡

When heated it is volatilized in a white smoke having the smell of garlic. When heated nearly to redness it burns with a pale bluish white flame, giving out white fumes having the smell of garlic.

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* Harepath. Phil. Mag. lxiv. 322.

† As quoted by Hauy.

‡ *Hoffman's Handbuch*, iv. 208.

John analyzed two specimens of native arsenic from Joachimsthal, and found the constituents

Arsenic,	96	97
Antimony,	3	2
Oxide of iron and water,	1	1
	100	100*

If the first of these specimens was a chemical compound of arsenic and antimony, it must have consisted of

{ 54 atoms arsenic,
1 atom antimony,

while the second would be a compound of

{ 82 atoms arsenic,
1 atom antimony,

But it is much more probable that the antimony is either only mechanically mixed, or at least combined with only a portion of the arsenic.

Native arsenic occurs most commonly along with those metallic ores that contain arsenic as a constituent; as arsenical pyrites, orpiment, grey copper, white cobalt, grey antimony, arseniet of nickel. In this way it is found at Kongsberg in Norway, at Andreasberg in the Hartz, and St. Marie aux Mines in France.

Sp. 2. *Arsenious Acid.*

White Arsenic.

This is rather a rare mineral; but it is met with in small quantities along with native arsenic, arseniet of cobalt, and sulphate of arsenic. The principal localities are Andreasberg in the Hartz, Joachimsthal, and St. Marie aux Mines.

Its colour is snow-white; it is either in stalactitical crusts or in small capillary prisms. The internal lustre is shining, and either glassy or silky.

It may be obtained artificially, crystallized in regular octahedrons; but under this form it has not yet been met with in the mineral kingdom. The specific gravity when pure is 8·729.†

Before the blowpipe it is completely volatilized in a white smoke. When exposed to the internal flame it becomes black, and gives out a strong smell of garlic. It dissolves in hot water, and the solution strikes a yellow with water impregnated with sulphuretted hydrogen.

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* Chemische Untersuchungen, i. 289.

† Harepath. Phil. Mag. lxiv. 322.

Sp. 3. *Arsenic Acid.*

The tendency of this acid to combine with bases is so great that in an isolated state it has not been met with in the mineral kingdom; but in combination with a base constituting an arseniate, it is by no means uncommon, no fewer than nineteen species being already known. These are,

1 4½ hydrous arseniate of lime,
2 Sesquihydrous arseniate of lime,
3 Diarseniate of iron,
4 Arseniate of iron,
5 Subsesquiarseniate of iron,
6 Scorodite,
7 Sulpho-arseniate of iron,
8 Diarseniate of nickel,
9 Diarseniate of cobalt,
10 Arseniate of lead,
11 Subsesquiarseniate of lead,
12 Diarseniate of copper,
13 Copper mica,
14 Prismatic oliven ore,
15 Acicular oliven ore,
16 Octahedral arseniate of copper,
17 Trisarseniate of copper,
18 Kapferschaum,
19 Ferruginous arseniate of copper.

These species will come under our consideration while treating of the various bases with which the arsenic acid is united.

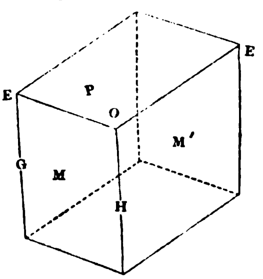
Sp. 4. *Sulphide of Arsenic.*

Realgar, red sulphuret of arsenic.

This mineral has a beautiful scarlet red colour, while its streak is orange yellow.

Its cross fracture is uneven, or sometimes imperfectly conchoidal; but it cleaves parallel to the planes of an oblique rhombic prism.

M on M′ 74° 15′, and the corresponding obtuse angle at the edge G 105° 45′. The terminal face P on M or M′ 104° 6′. The crystals of this substance hitherto met with have never the primary form. The solid angles E, E, are always replaced by small planes; the acute edges H of the prism are always replaced by two, and sometimes by three faces. In some crystals the obtuse edges G are also replaced by a tangent plane.



Hardness 1·5. It is brittle, and easily frangible. Its specific gravity, according to Brisson, is 3·384. Breithaupt found that of a crystallized specimen from Felsobanja 3·642.

Before the blowpipe it fuses easily, and burns with a blue flame, and is dissipated in fumes having the odour of garlic, and of sulphurous acid.

It is translucent, and the crystals are semitransparent. When rubbed, it acquires negative electricity.

Berzelius analyzed it and found it a compound of

Arsenic	4.68
Sulphur	2
	6·68

It is obvious from this that it is a sulphide, or a compound of 1 atom sulphur and 1 atom arsenic.

This mineral occurs along with native arsenic, and those metallic bodies such as cobalt and nickel, which are mineralized by arsenic. It is found at Andreasberg, in the Hartz, and beautiful crystals have been observed at Joachimsthal in Bohemia. It is said also to be found along with volcanic substances at Vesuvius, Solfatara, and Puzzola.

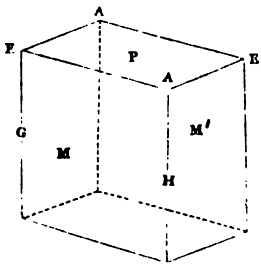
Sp. 5. *Sesquisulphide of Arsenic.*

Orpiment, yellow sulphuret of arsenic.

The colour is lemon yellow, and the streak has the same colour, but is rather paler.

The fracture is foliated, and the thin foliæ are flexible.

It occurs in very small crystals. Mr. W. Phillips has shown that the primary form is a right rhombic prism. M on M′ 100°. The edge G 80°. Sometimes the edge H is replaced by a tangent plane, sometimes by two planes. The angles A, A, and likewise the angles E, E, are occasionally replaced by planes intersecting the base P parallel to its diagonals. It cleaves also parallel to the diagonal E, E.



The lustre of the cleavage faces is metallic, pearly; every where else resinous.

Semitransparent, or at least translucent. Hardness 1·5. Specific gravity, according to Haidinger, 3·480[*] Breithaupt found that of a foliated specimen from Lower Hungary 3·4.* Brisson states it at 3·445.†

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[*] Mohs's Mineralogy, iii. 48.

The action of the blowpipe on it is the same as upon realgar.

From the analysis of Berzelius it is evident that this mineral is a compound of

1½ atom sulphur,	3
1 atom arsenic,	4·75
	7·75

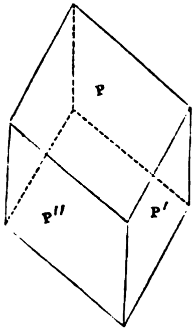
Orpiment occurs in the same situations as realgar; according to the Wernerians it is of rare occurrence in primary rocks, but much more frequent in the flœtz trap rocks. It is found in blue clay at Tasowa, near Neusohl, in Lower Hungary.‡

GENUS IX.—ANTIMONY.

This metal does not occur in nature in a great variety of forms. It is found native, though in that state it is rare; it is found united to arsenic and silver, constituting antimoniets of these metals. United to oxygen, it constitutes antimonious acid, and with sulphur sesquisulphide of antimony. The union of the two last species constitutes *red antimony.*

Sp. 1. *Native Antimony.*

This mineral was discovered by Anton Swab, in 1748, in the lead mine of Sala, in Westmanland.§ Afterwards it was found at Allemont, in France, and in other places.



The colour is tin-white, often tarnished; the fracture is foliated, and it cleaves, according to Mr. Brooke, parallel to the planes of an obtuse rhomboid.

P on P' about 117° Brook
117° 15' Haidinger.

But the measurements of different fragments do not agree within more than two degrees. Hauy considers the primary form obtained by mechanical division, to be the regular octahedron.

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* Haussmann's Handbuch, iv. 222.

† Ibid.

‡ Haidinger, Mohs's Mineralogy, iii. 49.

§ Kong. Vetensk. *Acad. Handl. 1748*, p. 99.

The lustre is metallic, and when newly broken splendent.

Opaque; hardness 2·5 to 3. Specific gravity as determined by Klaproth, in a specimen from Catharine Neufang mine at Andreasberg in the Hartz, 6·720.*

Before the blowpipe it melts, and is volatilized in a white smoke. Its constituents, as determined by Klaproth, are

Antimony	98
Silver	1
Iron	0·25
	99·25†

There can be no doubt that the silver and iron are merely accidental ingredients.

Sp. 2. *Arseniet of Antimony.*

This species is doubtless scarce, as it is not described in any mineral system which I have seen. The specimen in my cabinet is from Allemont.

The colour is reddish grey; the texture fine granular; the lustre metallic; opaque; hardness 3·5; specific gravity 6·130.

Before the blowpipe it smokes, emitting the smell of arsenic, melts into a metallic globule, which catches fire, and burns all away, leaving white oxide of antimony on the charcoal. The constituents were found to be

Antimony	46·612
Arsenic	38·508
Loss	14·880
	100·000

Probably it is a compound of

2 atoms arsenic	7·5
1 atom antimony	8
	15·5

This estimate is founded on the supposition that the loss was arsenic. If the loss consists both of antimony and arsenic, then the mineral is a compound of

11 atoms arsenic
8 atoms antimony

But the first supposition is the most probable of the two.

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* Beitrage, iii. 170.

† Ibid.

Sp. 3. *Protoxide of Antimony.*

White antimony—antimony bloom.

This mineral occurs in small quantity, in veins traversing primary or grey-wacke rocks. It usually accompanies the ores of antimony, and is very frequently attended by quartz.

Colour white, most commonly with a shade of yellow.

The fracture cannot be observed, but it occurs in crystals which are usually very thin four-sided prisms, having very much the aspect of split straw. At Braunsdorf near Freiberg, it has been found in sulphuret of lead in pretty large six-sided prisms. According to Mr. Phillips it yields to mechanical division parallel to the sides of a rhombic prism of 137° 43′, and 42° 17′; but the principal cleavage is parallel to the shorter diagonal of the prism.*

The lustre is adamantine and shining. It is semitransparent, or at least translucent. Hardness 2·5 to 3; specific gravity 5·566.†

Before the blowpipe it melts easily, and is volatilized in a white vapour. Indeed it fuses when simply held in the flame of a candle.

It is protoxide of antimony mixed or combined with a little silica. A specimen from Braunsdorf analyzed by Vauquelin, was composed of

Oxide of antimony	86·
Ditto and iron	3·
Silica	8
	97‡

This approaches to 3 atoms silica
7 atoms oxide of antimony.

It may perhaps be a disilicate of antimony, or a compound of

1 atom silica . . .	2
2 atoms protoxide of antimony	19
	21

But this can only be determined by a new analysis, and the mineral is so scarce that it is not easy to procure a sufficient quantity for such a purpose.

It was first found at Przibram in Bohemia, and afterwards at Braunsdorf, in Saxony. It is found also at Malaczka, in Hungary, in Baden, in Nassau, and at Allemont in Dauphiny.§

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* Mineralogy, p. 331.

† Mohs' Mineralogy, ii. 152.

‡ Hauy, iv. 309.

§ Mohs, ii. 154.

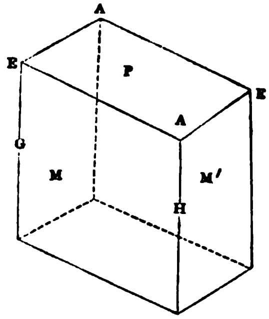
Sp. 4. *Sesquisulphide of Antimony.*

Grey antimony—crude antimony—sulphuret of antimony.

This species constitutes the great ore of antimony, from which all the antimony of commerce is extracted.

The colour is lead grey, inclining to steel grey. It has the metallic lustre, and is specular splendent, except when in minute capillary crystals, when it is nearly dull.

The primary form of the crystal is a right rhombic prism. M on M′ 91° 30′, by Mr. Phillips' measurement. Mr. Brooke found M on M′ 90°, but observes that the secondary forms of the crystals show that it is not rectangular, but rhombhoidal. In many cases the acute edges G of the prism are replaced by tangent planes. In some the terminal faces P of the prism are surmounted by four-sided pyramids, the faces M, M′ making angles of 145° 30′, with the corresponding faces of the pyramid. These two modifications sometimes occur together.



When the crystals are large enough to observe the texture, the mineral is foliated. The thin plates are very flexible. Opaque; sectile; hardness 2. Specific gravity, as determined by Mohs 4·620;* according to Hauy, it is 4·516.†

When placed in the flame of a candle it melts. Before the blowpipe it is dissipated in a white vapour, which coats the charcoal, and gives out at the same time the smell of burning sulphur. I found its constituents to be

Antimony	73·77
Sulphur	26·23
	100·00

This amounts nearly to

1 atom antimony	8
$1\frac{1}{2}$ atom sulphur	3
	11

The mineral is therefore a sesquisulphide.

The compact varieties of this species occur most commonly in beds; but the crystallized and foliated varieties are confined to veins. In Great Britain it has been wrought only in Cornwall, where a pretty rich mine of it exists, Huel Boys, Endellion, near Padstow. There was another mine of it at Saltash on the borders of Devonshire, near Plymouth, which yielded considerable quantities of crude antimony about the year 1776. It is found at Glendinning, in Dumfries-shire; but I am not aware that the mine has ever been wrought. It occurs at Pösing, near Presburg, in Hungary, and in other localities of that country. It is found also in Saxony, and beautiful specimens are brought from the department of Puy-de-Dome, in France.

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* Mineralogy, iii. 24.

† Mineralogie, iv. 292.

Sp. 5. *Red Antimony.*

This is rather a rare mineral. In small quantities it is often associated with sesquisulphide of antimony. It has been supposed by some that it owes its origin to a partial decomposition of the sesquisulphide of antimony.

Colour cherry red; the fracture, when observable, is foliated.

It most commonly occurs in delicate capillary crystals, which Mr. Phillips thinks have for their primary form a right square prism, having the edges commonly replaced by a tangent plane. Mohs considers the primary form as an octahedron, having a rhombic base.

Lustre shining, and approaching the adamantine; feebly translucent; sectile; the thin laminæ slightly flexible; hardness 1 to 1·5. Specific gravity, as determined by Klaproth, 4·090.* According to Mohs, it is from 4·5 to 4·6.†

Before the blowpipe it melts, and is volatilized, giving out a sulphureous odour. When plunged into nitric acid it becomes covered with a white coating.

From the late investigations of M. H. Rose, we learn that this mineral is a compound of

1 atom oxide of antimony . .	9·5
2 atoms sesquisulphide of antimony	22
	31·5

Red antimony is found at Braunsdorf, in Saxony, Allemont, in France, in Tuscany, and in Hungary and Transylvania. It has been met with in veins only.

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* Beitrage, iii. 179.

† Mineralogy, iii. 37.

GENUS X.—CHROMIUM.

Chromium in the metallic state has not yet been observed, either isolated or in combination with other bases. The green oxide of chromium, and chromic acid are not uncommon, and always in combination with a base.

Oxide of chromium exists in chrome iron ore, where it acts the part of an acid. The mineral being a compound of

$\begin{cases} \text{1 atom chromite of iron,} \\ \text{1 atom chromite of alumina.} \end{cases}$

Chromic acid united to oxide of lead constitutes several mineral species, namely,

Chromate of lead,
Dichromate of lead,
Cupreochromate of lead,
Chromo-phosphate of lead.

Of these, chrome iron ore is by far the most abundant, and the most valuable. These species will come under our review in a subsequent part of this work.

GENUS XI.—MOLYBDENUM.

Molybdenum has never been found native in the metallic state. It exists in the form of molybdic acid, combined with oxide of lead, and constituting *molybdate of lead*, a species which will come to be described under the genus *lead*.

Molybdenum exists also united to sulphur, constituting the only species belonging to this genus.

Sp. 1. *Bisulphide of Molybdenum.*

Molybdena—wasserblei—molybdenglanz.

The colour of this mineral is lead grey. It has the metallic lustre, is splendent, and the streak is unchanged.

The fracture is foliated; the plates are easily separated from each other, and when sufficiently thin, are flexible, but not elastic. The mineral is sectile, and almost malleable.

The crystal is the regular six-sided prism of unknown dimensions; but it always occurs very short. Schmeisser, in the second volume of his mineralogy, says, that he saw crystals of it in the possession of Mr. Raspe, which were six-sided prisms terminated on both ends by six-sided pyramids; but I am not aware of any such crystals at present existing in cabinets.

Opaque; hardness 1 to 1·5; specific gravity, as determined by Karsten, 4·569; by Brisson, 4·7385.

Before the blowpipe, it does not melt nor is reduced; but it emits fumes, which are deposited upon the charcoal, while at the same time a sulphureous odour is exhaled.

It was first analyzed by Bucholz, who found its constituents

2 atoms sulphur, . .	4
1 atom molybdenum, . .	6
	10[*]

It is found in small pieces, or in crystals, most frequently in granite or gneiss. Its oldest localities are Altenberg, in Saxony, and Schlaggenwald and Zinnwald, in Bohemia, where it accompanies tin ore. It is found in a similar situation in Cornwall, and abounds in the primary rocks of the United States of America. In Norway, it occurs imbedded in the zirconsyenite rock of the neighbourhood of Christiania.

GENUS XII.—TUNGSTEN.

Tungsten has not been observed in the metallic state in the mineral kingdom. It is always under the form of tungstic acid; and as this acid is constantly united to an alkaline base, the species of minerals containing it will come to be described under their respective bases. They are the following:—

1 Tungstate of lime,
2 Wolfram,
3 Sesquitungstate of lead.

GENUS XIII.—COLUMBIUM.

Columbium, like the preceding metal, occurs only in the state of peroxide, or columbic acid, which is always united to an alkaline base. The species hitherto met with are the following:—

1. Yttro-tantalite, under which name three species of minerals are included; namely,

(1.) Columbate of yttria,
(2.) Dicolumbate of yttria,
(3.) Triscolumbate of yttria.

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[*] Gehlen's Jour. iv. 60.

2. Fergusonite.
3. Columbite, or tantalite.

These species will be described in a subsequent part of this work.

GENUS XIV.—TITANIUM.

This metal in the metallic state has been observed only in the slag at the bottom of iron furnaces. It combines with two proportions of oxygen, constituting the protoxide of titanium and titanic acid. Both of which have been observed native, though the latter is never in a state of purity. Titanic acid combines with the oxide of iron in various proportions, and constitutes at least five different species, which will be described when we come to treat of the genus *Iron*. Here we have only to give an account of titanium and its two oxides.

Sp. 1. *Native Titanium.*

The existence of this metal in a state of purity in the slag of Merthyr Tydvil furnaces, in South Wales, was discovered by Dr. Wollaston in 1822.*

The colour is copper-red, and the titanium is usually under the form of small cubes with smooth surfaces.

Lustre splendent and metallic; hardness 7·5; opaque; specific gravity 5·3.

The crystals are infusible before the blowpipe. They are not sensibly acted on by acids. They may be oxidized when heated with a mixture of nitre, borax, and carbonate of soda. They are good conductors of electricity.

These crystals consist of titanium in the metallic state, and nearly pure. I found traces of iron in some of the cubes, but am not quite certain that the iron may not have been mechanically mixed. The cubes, however, had been repeatedly digested in muriatic acid.

This reduced titanium was found at the bottom of the furnaces at Merthyr Tydvil, when these furnaces were cleared out. It has been met with in other places. For example, Professor Walchner found it in the iron slag at Carlsruhe.† It was found also lately at the bottom of the furnace at Muirkirk, in Ayrshire.

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* Phil. Trans. 1823, p. 17.

† Schweigger's Jahrbuch, xvii. 118.

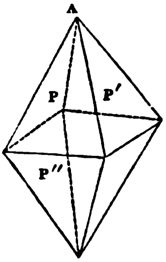
Sp. 2. *Protoxide of Titanium.*

Anatase—octahedrite—oisanite.

This mineral was discovered by Count Bournon in 1783, near the town of Oisan, in the department of the Isere, and called by him *blue schorl.* Saussure afterwards described it, and gave it the name of *octahedrite*, while Hauy distinguished it by the name of *anatase.*

Its colour, when pure, seems to be indigo *blue;* but more commonly it appears, by reflected light, *clove brown* or *steel-grey:* by transmitted light it is greenish yellow, or blue. Its fracture is foliated, and the cleavage planes are parallel to the faces of an octahedron.

It has been only found crystallized. The primary form is an octahedron with a square base.



P on P′ 98°.
P on P″ 136° 12′

Sometimes the summit A is replaced by a small square parallel to the base of the pyramid. P or P′ makes with that face an angle of 111° 17′. Sometimes the summit A is replaced by a low four-sided pyramid, P making with the corresponding face of this small pyramid an angle of 131° 21′. Sometimes the small pyramid replacing A is eight-sided.

Lustre splendent and adamantine. It varies from semi-transparent to opaque; hardness 5·5 to 6; specific gravity, as determined by Hauy, 3·857,[*] by Mohs 3·826.[†]

Before the blowpipe, it exhibits the phenomena of oxide of titanium.[‡]

By the analysis of Vauquelin, it is pure oxide of titanium. From the colour, I am disposed to consider it as the protoxide of that metal. It is certainly not titanic acid, which when pure is white.

This mineral is rare. In Dauphiny, it occurs in veins in primary rocks along with albite, axinite, rock-crystal, and chlorite. Bournon says, that he possessed a crystal of it from Cornwall in granite. It has been found also in Norway by Von Buch; in Spain, and in Brazil.[§]

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[*] Mineralogie, iv. 344.

[†] Mineralogy, ii. 380.

[‡] Berzelius on the blowpipe, p, 140.

[§] Mohs, ii. 380.

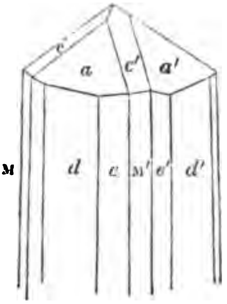
Sp. 3. *Titanic Acid.*

Crispite, gallizinite, rutile, sagenite, titanite.

This mineral usually occurs in veins passing through primary rocks. It has been met with in many different places. I have fine specimens from Glen Tilt, in Perthshire. St. Yrieiz, in France, is the most abundant locality; but the variety of situations in which it is found is so great, that it would be impossible to enumerate them all. Its peculiar nature was first pointed out by Klaproth in 1795.

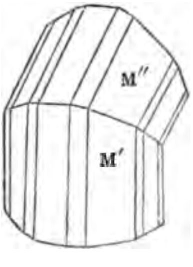
The usual colour is brownish-red, more inclined to brown when the specimen is opaque, and to red when it is transparent.

Most commonly crystallized. The fracture, when observable, is foliated, the cleavage being parallel to the lateral faces, and to the diagonals of a right square prism; which must therefore be considered as the primary form. In some crystals the lateral edges are replaced by tangent planes; in others, by two planes; and in some, both of these modifications occur together. The prism is frequently terminated by a four-sided or eight-sided pyramid. The figure in the margin exhibits at one view most of these modifications.



M on d, or M′ on d′, 132° 32′.
M′ on e′ 161° 40′.
M on c, or M′ on c′, 122° 45′.
a on d 132° 20′.
d on e 153° 33′.
a on a over summit 90°.
c on c ditto 109° 47′.
a on a′ 123° 15′.
a on c 151° 42′.

The crystals are longitudinally striated. They often occur penetrating transparent quartz. Sometimes small needle-form crystals are met with intersecting each other like a net. It was this circumstance which induced Saussure to give the mineral the name of sagenite. Geniculated crystals frequently occur, consisting of twin crystals united together lengthways, and making an angle with each other, as represented in the margin.



M′ on M″ 134° 52′.

Hardness 6·5 to 7; specific gravity as determined by Klaproth 4·18;[*] as determined by Mohs 4·249.[†] The last specific gravity was that of a dark-coloured variety from Ohlapian.

Before the blowpipe it is not altered. It dissolves in borax, forming a hyacinth red bead. It does not fuse with biphosphate of soda, though it communicates a pale red colour.

Klaproth considered it a pure titanic acid, but Rose has shown that it contains iron, and that it owes its colour to the presence of the oxide of that metal. We are not yet in possession of an exact analysis. Should the iron amount to an atomic proportion, titanic acid will require to be transferred to the genus *iron*, and described as a *titaniate* or *supertitaniate of iron.*

GENUS XV.—VANADIUM.

Vanadium has not hitherto been discovered in the metallic state. The minerals at present known contain it in the form of vanadic acid. Only one species has been hitherto met with; namely,

Vanadiate of Lead.

It will come to be described under the genus *lead.*

CLASS II.

ALKALINE BASES.

There are 27 alkaline bases which occur in the mineral kingdom. These are,

1 Ammonia,
2 Potassium,
3 Sodium,
4 Lithium,
5 Barium,
6 Strontium,
7 Calcium,
8 Magnesium,
9 Aluminum,
10 Glucinum,
11 Yttrium,
12 Cerium,
13 Zirconium,
14 Thorium,
15 Iron,
16 Manganese,
17 Nickel,
18 Cobalt,
19 Zinc,
20 Lead,
21 Tin,
22 Bismuth,
23 Copper,
24 Mercury,
25 Silver,
26 Uranium,
27 Palladium.

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[*] Beitrage, i. 234.

[†] Mineralogy, ii. 377.

Each of these bases constituting a genus, it is obvious that this second class comprehends under it no fewer than 27 genera of minerals.

GENUS I.—AMMONIA.

Though ammonia rather belongs to the animal than the mineral kingdom, yet there are a few ammoniacal salts occasionally met with, chiefly in the neighbourhood of volcanoes, which are usually enumerated as mineral species. These we shall notice in this place.

Sp. 1. *Sal Ammoniac.*

This salt occurs in the immediate vicinity of active volcanoes, and is formed by sublimation. Its best known localities are Vesuvius, Etna, Solfatara, &c. It is formed also during the combustion of pitcoal, and sublimes in the brick kilns in the neighbourhood of London, during the baking of the bricks.

Colour usually white; often inclining to grey or yellow.

Occurs in powder, in fibrous masses, in crusts, and in regular crystals, which have most commonly the form of what is called the *leucite crystal;* that is, a crystal approaching the spherical form, and bounded by 24 trapezoidal faces. The nature of this crystal will be explained under the species *leucite.* The primary form of this salt is a cube, and the leucite crystal is formed when each angle of the cube is replaced by three planes, and when these planes increase so much as to obliterate the original faces of the cube.

Lustre vitreous; hardness 1·5 to 2; very sectile; specific gravity 1·528; taste saline and pungent; sublimes when heated; soluble in water.

The sal ammoniac from Vesuvius was found by Klaproth composed of

Pure sal ammoniac . .	99·5
Common salt . .	0·5
	100

That from Bucharia consisted of

Sal ammoniac . .	97·5
Sulphate of ammonia .	2·5
	100·0*

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* Beitrage, iii. 89.

Sp. 2. *Sulphate of Ammonia.*

Mascagnine.

This salt is met with in the neighbourhood of Etna and Vesuvius, &c.

Colour yellowish grey, lemon yellow.

Occurs in mealy crusts and stalactites.

Translucent; lustre vitreous, after solution in water and crystallization; taste pungent and bitter; soluble in water.

It has not been subjected to analysis, but is probably nearly pure sulphate of ammonia.

GENUS II.—POTASSIUM.

Potassium has so strong an affinity for oxygen that its existence in the metallic state, at least within reach of the atmosphere, is out of the question. Combined with oxygen in the state of potash it is not an uncommon constituent of minerals; but only a single species occurs, in which it constitutes the only alkaline ingredient united to an acid.

Sp. 1. *Nitrate of Potash.*

Saltpetre, nitre.

This salt occurs in small needle form crystals on the surface of the earth, on walls, rocks, &c., in many parts of the world; in none more abundantly than in India, whence we are supplied with all the nitre which we require.

Colour white; taste cooling and bitter; when thrown on burning coals it deflagrates with great splendour; specific gravity 1·933.

The primary form of saltpetre, according to Hauy, is an octahedron with a rectangular base, but it crystallizes commonly in six-sided prisms, which are striated longitudinally. When pure it is a compound of

1 atom nitric acid . .	6·75
1 atom potash . . .	6
	12·75

But it almost always contains a mixture of chloride of potassium, common salt, sulphate of potash, and not unfrequently nitrate of lime. These foreign salts sometimes amount to 25 per cent. of the nitre; but in fine samples from India I have found no more than 5 per cent. of impurity. In these fine samples the calcareous salts are altogether wanting.

There are 26 species of minerals in which potash occurs as one of the bases. These will be described under the genus *aluminum*, as they all contain a considerable proportion of alumina as a constituent. We shall merely give a list of their names:

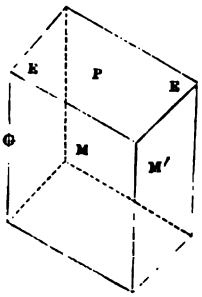
1 Ice spar,
2 Killinite,
3 Leucite,
4 Gabronite,
5 Felspar,
6 Kaolin,
7 Leelite,
8 Lepidolite,
9 Rhomboidal mica,
10 Brown scaly mica,
11 Anthophyllite,
12 Hydrous ditto,
13 Gieseckite,
14 Diploite,
15 Pinite,
16 Glauconite,
17 Marchesonite,
18 Nutallite,
19 Phyllite,
20 Pearl stone,
21 Antrimolite,
22 Ittnerite,
23 Hydrolite,
24 Agalmatolite,
25 Morvenite,
26 Apophyllite.

GENUS III.—SODIUM.

Sodium, like potassium, occurs in the mineral kingdom only in the state of soda, constituting the base of various salts. Those in which it exists simply united to an acid belong to this genus. But the various minerals in which soda is associated with other bases will be described when we come to treat of those bases that constitute the greater proportion of the compound. The simple soda salts belonging to this genus are seven in number.

Sp. 1. *Carbonate of Soda.*

From the observations of Klaproth, it appears that the common crystallized carbonate of soda occurs at Debrezin, in Hungary, and Monte-nuovo, near Naples.*



It is usually effloresced, and in powder, from the loss of its water of crystallization, but it is easily crystallized artificially. The primary form is an oblique rhombic prism.

P on M or M′ 108°43′.
M on M 76° 12.

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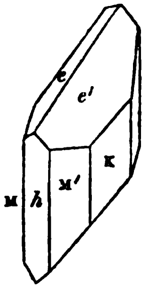
* Beitrage, iii. 83.

But the most common modification of the crystal is that represented in the figure in the margin, in which the edges G are replaced by tangent planes *h*, and the solid angles E, E are replaced by two planes.



Its taste is alkaline, but much less acrid than the carbonate of potash. When exposed to the air it effloresces.

Sp. 2. *Sesquicarbonate of Soda.*

Natron, trona, borech, urao.

This mineral occurs in great abundance in the province of Suckena, which belongs to Tripoli, in Africa, and lies at the distance of 28 days journey from the town of Tripoli, or two days journey from Fezzan. The mineral is found at the foot of a mountain, and forms a crust, varying from the thickness of an inch to that of the back of a knife.*

It is in crystals adhering together, and constituting parallel or oblique four-sided prisms. It is often in fibrous masses, seemingly consisting of a congeries of minute crystals.

Lustre vitreous glistening; translucent; colour grey, or yellowish-white; taste alkaline, but mild; soluble in water; not altered by exposure to the atmosphere.

A specimen of the African natron, analyzed by Klaproth, was a compound of

Carbonic acid, .	38
Soda, . .	37
Water, . .	22·5
Sulphate of soda, .	2·5
	100†

This is obviously equivalent (leaving out the sulphate of soda) to

$1\frac{1}{2}$ atom carbonic acid, .	4·125 .	38·76
1 atom soda, . . .	4·000 .	37·59
2 atoms water, . . .	2·250 .	21·14
	10·375	97·49

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* Bagge, Kongl. Vet. Acad. Handl. 1773, p. 140.

† Beitrage, iii. 80.

When this salt is crystallized artificially, it forms doubly oblique prisms. But I have never obtained crystals sufficiently perfect for measurement.

From a paper by Mariano de Rivero and Boussingault,* it is evident that the *Urao* which occurs at the bottom of a lake, a day's journey from Merida in South America, is a sesquicarbonate of soda. For they found its constituents to be

		Atoms.
Carbonic acid, .	39	1·37
Soda, . . .	41·22	1
Water, . .	18·80	1·62
Foreign bodies, .	0·98	
	100	

There is a slight deficiency both of acid and water, provided the analysis be correct.

Sp. 3. *Nitrate of Soda.*

An immense deposite of this salt has been recently discovered in the district of Tarapaca, near the northern frontier of Chili, constituting a bed several feet thick, and extending over a space 40 leagues in length. The salt is sometimes in a state of efflorescence, sometimes crystallized, and most frequently mixed with clay and sand. Here and there it contains nests of common salt, and it is seldom free from an admixture of nitrate of potash. Great quantities of it have been brought to Europe, and in Great Britain it is beginning to be employed in the manufactures instead of nitre. I have not ventured to describe it, because I suspect that it has undergone solution and crystallization before it is imported into Great Britain.

Sp. 4. *Hydrous Sulphate of Soda.*

Glauber's salt.

This salt is found occasionally in the neighbourhood of mineral springs. It occurs near Aussee, Ischel, and Halstadt in Austria, at Hallein in Saltzburgh, in Hungary, Switzerland, Italy, Spain, &c.

It is commonly in the state of an effloresced powder; sometimes massive, and sometimes, it is said, crystallized in needles and six-sided prisms; but I have never seen it in that state.

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* Ann. de Chim. et de Phys. xxix. 110.

Sp. 5. *Anhydrous Sulphate of Soda.*

Thenardite.

This salt exists at Espartine, about five leagues from Madrid, and two and a-half from Aranjuez. During winter, salt water exudes from the bottom of a basin, and during summer, the liquid becomes concentrated, and deposits crystals of anhydrous sulphate of soda.

They have the form of octahedrons with a rhomboidal basis. They have three cleavages, indicating a right oblique prism with rhomboidal bases, the angles of which are about 125° and 55°. The height of the prism is to a side of its base, as 7 to 3.*

The crystals are translucent; lustre vitreous; specific gravity 2·73.

According to the analysis of M. Casaseca, the constituents are

Anhydrous sulphate of soda,	99.78
Carbonate of soda, .	0·22
	100†

This salt is easily obtained artificially, by keeping a saturated solution of Glauber salt at the temperature of 106°.

Sp. 6. *Borax.*

Pounxa, swaga, tincal, zala, biborate of soda.

This mineral (till within these few years) was brought chiefly from Thibet, where it is procured from a lake which is entirely supplied by springs, and is fifteen days journey from Tisoolumbo, the capital. The water contains both borax and common salt, and being in a very high situation, is frozen during the greater part of the year. The edges and shallows of the lake are covered with a stratum of borax, which is dug up in considerable masses; and the holes thus made are gradually filled up by a fresh deposition.

Its colour is white, but it sometimes has a shade of blue or green.

Lustre vitreous, sometimes earthy.

It is often crystallized in six-sided flat prisms, variously terminated, but yielding to mechanical division, parallel to the faces of a doubly oblique prism.

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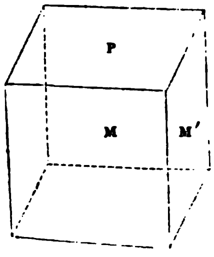
* Cordier, Ann. de Chim. et de Phys. xxxii. 309.

† Ibid. p. 311.



M on M′ 86° 30′
P on M or M′ 101° 30

The edges of the prism are often replaced by planes, converting the crystals into a six or eight-sided prism.

Varies from translucent to opaque.

The crystals are often coated with a kind of fatty matter. When heated they frequently blacken and undergo a kind of combustion, indicating the presence of some foreign matter. It froths and swells before the blowpipe, and at last fuses into a transparent globule.

Borax is said to be found also in China, Ceylon, Potosi, and in different places of Europe, viz. Transylvania, Lower Saxony, and Tartary.

Sp. 7. *Common salt.*

Rock salt, salgemme, muriate of soda, chloride of sodium.

This important salt is found in immense beds, situated most commonly in the new red sandstone; though it is occasionally met with in older formations. Poland, Hungary, England, &c., may be mentioned as localities.

Colour generally white, passing into yellow, flesh red, and ash grey. Sometimes blue, streak white.

Frequently in crystals. Primary form the cube. Sometimes the angles and sometimes the edges of the cube are replaced by tangent planes. When these new faces become so much enlarged as to obliterate the original faces of the cube, the regular octahedron and the rhomboidal dodecahedron are produced.

Lustre vitreous, shining; transparent to translucent; rather brittle; hardness 2. Specific gravity, as determined by Mohs, 2·257; taste saline.

Decrepitates before the blowpipe, deliquesces in a moist atmosphere.

It consists essentially of chloride of sodium; but is almost always mixed with a little sulphate of lime, chloride of calcium, and chloride of magnesium.

The minerals containing soda as an essential, though not the only base, are 29 in number. Their names are as follows:

1 Glauberite,
2 Reissite,
3 Soda-alum,
4 Cryolite,
5 Nephelin,
6 Sodalite,

7 Achmite,
8 Blœdite,
9 Pipestone,
10 Albite,
11 Ryacolite,
12 Keiselspath,
13 Elœolite,
14 Commingtonite,
15 Natrolite,
16 Mesolite,
17 Ithnerite,
18 Chalilite,
19 Harringtonite,
20 Levyne,
21 Analcime,
22 Lehuntite,
23 Cluthalite,
24 Bytownite,
25 Cauzeranite,
26 Retinalite,
27 Labradorite,
28 Pitchstone,
29 Obsidian.

These will come to be described chiefly under the genus *alumina*, to which the greater number of them belong.

GENUS IV.—LITHIUM.

Lithium, like potassium and sodium, never occurs in the mineral kingdom in an isolated state; but always united to oxygen, and constituting the alcali, *lithia*. No mineral species is known composed of an acid united to lithia alone. All those which contain it are compound salts, and of course coming to be described under subsequent genera. We shall here merely give the names of those species which contain lithia as a constituent. They are 5 in number.

1 Spodumen,	$4AlS^2+LS^2$
2 Petalite,	$3AlS^4+LS^3$
3 Ambligonite,	$3Al\dot{P}h+L\dot{P}h$
4 Tourmalin,	$14AlS+\underline{mn}S^2+L\dot{B}^2$
5 Lepidolite,	$6AlS+2LS+KS$

GENUS V.—BARIUM.

Barium, like the preceding bases, has been found only in the mineral kingdom united to oxygen and constituting *barytes*. Hitherto barytes has been found almost exclusively combined with carbonic acid or sulphuric acid.

Sp. 1. *Carbonate of Barytes.*

Barolite, witherite.

This mineral was first observed at Alston moor in Cumberland, along with galena, in veins passing through the coal formation. It was described and its nature pointed out by

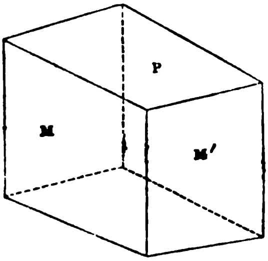
Dr. Withering in 1784.* Hence the name *witherite*, by which Werner distinguished it.

Its colour is grey, most commonly with a shade of yellow. It is said also to occur with a shade of blue, green, and red.

The principal fracture is fine radiated or fibrous, the cross fracture is uneven, inclining to splintery.

It occurs crystallized, most commonly in six-sided prisms terminated by six-sided pyramids, resembling at first sight the most common form of rock crystal. Sometimes the summit of the pyramid is replaced by a plane parallel to the base of the prism. The primary form seems to be a right rhombic prism.

M on M′ (according to the measurement of Mr. W. Phillips) 118° 30′.



The six-sided prisms are probably macles, resulting from the intersection of the primary crystals.

Lustre of the principal fracture shining, of the cross fracture glistening; lustre resinous.

The crystals (which are small) are semi-transparent; the massive varieties are only translucent; hardness, 3·75. I found the specific gravity of a fine specimen from Anglesark, 4·2985. Hauy states it at 4·2919.† Mohs makes it 4·301.‡

Before thè blowpipe it fuses readily into a clear glass, which in cooling becomes a white enamel. On charcoal it effervesces strongly, becomes caustic, and then is absorbed by the charcoal. With borax and with biphosphate of soda it melts into a clear glass, which becomes opaque and white on cooling, if the quantity of carbonate of barytes bear a sufficient proportion to that of the fluxes.

Klaproth found the Stirian variety of this mineral pure carbonate of barytes, composed of

1 atom carbonic acid, .	2·75
1 atom barytes, . .	9·50
	12·25§

The Anglesark variety contains according to this analysis 1·7 per cent. of carbonate of strontian, a trace of copper, and a

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[*] Phil. Trans. 1784, p. 293.

[†] Mineralogie, ii. 25.

[‡] *Mineralogy*, ii. 120.

[§] Beitrage, i. 271.

small quantity of alumina and iron.* In every specimen which I examined, I found *carbonate of lead*, and in a specimen from the north of England, I found a little carbonate of lime.

It is by no means scarce in the lead mine district in the north of England, where it accompanies galena in the veins. Withering says, that the specimen which he examined came from Alston Moor; but Klaproth assures us, I know not on what authority, that it came in reality from Anglesark in Lancashire, where it is known to exist in considerable quantity, but never quite free from carbonate of lead. It has been found near Neuberg in Stiria, in irregular beds. Hungary, Salzburgh, Siberia, Sicily, are also mentioned as localities.

Sp. 2. *Sulphate of Barytes.*

Baroselenite, heavy spar, aehrensten, Bolognian spar, cawk, hepatite, litheospore.

This mineral is rather abundant, and it occurs both in beds and veins; though the finest and most beautiful specimens are met with in veins.

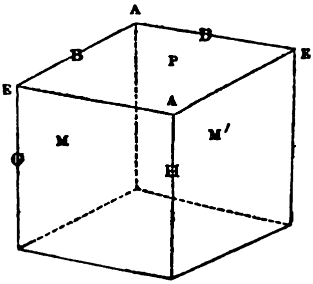
Its colour when pure is snow-white; but it has frequently a shade of red, yellow, blue, or green. In some cases the colour is brown or even brownish black.

The fracture is usually foliated; though in some varieties it is radiated, and in others fibrous.

It occurs very frequently crystallized, and the primary form is a right rhombic prism, in which

M on M′ 101° 42′

Sometimes the edges H, and sometimes the edges G, are replaced by tangent planes. Sometimes the angles A, sometimes the angles E, are replaced by triangular planes. The former parallel to the long diagonal, and the latter to the short diagonal of the base of the prism. The enlargement of these secondary planes at the expense of the primary faces of the crystal, occasion the different forms which have been described and figured by Hauy.†



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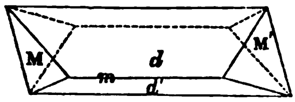
* Beitrage, ii. 86.

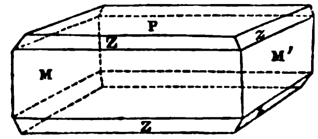
† See his Atlas, *from plate 33 to plate 42,* both inclusive. The *varieties figured are 72 in number.*

When the faces replacing A acquire such a size that they meet, the base of the prism disappears, and the faces M, M′ become triangular. Thus the crystal is changed into an octahedron. And most frequently it is elongated as in the figure in the margin, where M, M are the faces of the primary form, represented by the same letters as in the former figure, *d*, *d′* are the faces that replace the angles A, much enlarged, and *m*, in the cuneo form ridge of the octahedron. A somewhat similar octahedron is sometimes produced by the enlargement of the faces replacing the angles E, in the primary form.



These two replacements sometimes occur together concealing all the primary faces, and constituting a kind of octahedron.

Sometimes all the edges of the base of the primary prism are replaced by tangent planes, Z, Z, Z, represent these planes of replacement in the figure in the margin.



These are the most remarkable modifications of the primary form. For a description of the rest, the reader is referred to Hauy, and for the measurement of the inclination of the secondary faces to each other, and to the primary faces, to Phillips.*

The lustre is commonly pearly, and varies from glimmering to splendent, according to the purity and state of the specimens.

Sometimes it is opaque, and sometimes translucent on the edges. The crystals are always translucent and sometimes transparent. They refract doubly.

Hardness 3 to 3·5. I found the specific gravity of a pure transparent colourless crystal 4·4720. Mohs states the specific gravity at 4·446.† According to Hauy it varies from 4·2984 to 4·4712.

Before the blowpipe it decrepitates but is not easily fused. This difficult fusibility constitutes a good mark of distinction between this mineral and sulphate of lime, or of strontian. In the blue flame, it is converted into sulphuret of barium, characterized by its pungent and hepatic taste.

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* Mineralogy, p. 184.

† Mineral. ii. 123.

When pure, it is composed of

1 atom sulphuric acid, .	5
1 atom barytes . .	9·5
	14·5

It occurs in almost every country, chiefly in veins. In the north and middle counties of England, fine crystallized specimens are met with in the veins accompanying galena.

The sub-species into which it has been divided by Werner, are scarcely entitled to the minute attention which they have received from him.

Sp. 3. *Calcareo-sulphate of Barytes.*

This species, hitherto overlooked by mineralogists, occurs rather abundantly in the lead mine of Strontian in Argyleshire, which occupies a vein dividing the granite from the gneiss. It is the common gangue of the galena.

Colour snow-white; texture foliated. I have never met with a specimen of it crystallized. Very frangible; hardness 2·75; translucent on the edges. Specific gravity 4·1907. Before the blowpipe decrepitates, but does not fuse.

I subjected the purest specimen that I could select to analysis. The result was as follows:

		Atoms.
Barytes, . .	48·945	5·15
Strontian, . .	0·790	0·12
Lime, . .	6·605	1·88
Sulphuric acid, .	35·230	7·05
Silica, . .	4·140	2·07
Alumina, . .	3·460	1·53
Protoxide of iron, .	0·450	0·10
Moisture, . .	0·565	
	100·185	

It is obvious that the sulphuric acid just saturates the barytes, strontian, and lime. Hence the other constituents are accidental. The mineral (if we include the strontian with the lime) is obviously a compound of

1 atom sulphate of lime,
$2\frac{1}{2}$ atoms sulphate of barytes.

Probably this species occurs in other localities besides Strontian; though hitherto it has been confounded with sulphate of barytes; from which it is easily distinguished by its inferior hardness and specific gravity. The sulphate of barytes stated by Hauy to be as low as 4·2984, probably contains at least a portion of calcareo-sulphate.

Sp. 4. *Baryto-calcite.*

There is another species of calcareous sulphate of barytes which occurs in Yorkshire, between Leeds and Harrowgate, connected with the millstone grit and mountain limestone beds, which occur in such abundance in that country.

Colour white.

Texture foliated.

Translucent, at least on the edges.

Lustre silky.

Hardness 4; exceedingly brittle, and very easily frangible.

Specific gravity 3·868.

Its constituents, by my analysis, are

Sulphate of lime, . .	71·9 .	$4\frac{1}{2}$ atom,
Sulphate of barytes, .	28·1 .	1 atom.
	100·0	

The foreign matter amounted to about $1\frac{1}{2}$ per cent., and consisted of iron shot sand, seemingly introduced by the infiltration of rain water.

Sp. 5. *Sulphato-carbonate of Barytes.*

This mineral occurs in Brownley hill mine in the county of Cumberland. I found the only specimen which I have seen in a collection of minerals exposed to sale in Glasgow, in November, 1834, by Mr. Cowper, a mineral dealer from Alston Moor.

Colour snow-white.

The specimen consists of a congeries of very large six-sided prisms, terminated by low six-sided pyramids. The surfaces are so rough and irregular that it was impossible to measure the angles with any certainty. One of the angles of the six-sided prism measured about 130°.

Texture seemed foliated, but no regular cleavage was discovered.

Lustre vitreous; translucent.

Hardness about 3; specific gravity 4·141.

On subjecting it to analysis, I obtained

		Atoms.
Sulphate of barytes, . .	34·30	. 1
Carbonate of barytes, . .	64·82	. 2·2
Carbonate of lime, . .	0·28	
Moisture, ...	0·60	
	100·00	

I think it probable from this analysis that the true constituents are

1 atom sulphate of barytes,
2 atoms carbonate of barytes.*

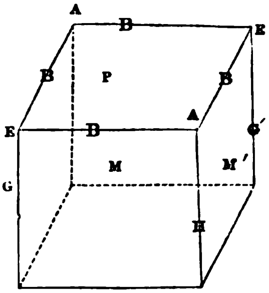
GENUS VI.—STRONTIUM.

Strontium, like barium, never occurs in the mineral kingdom except in combination with oxygen, and constituting *strontian.* Strontian, in the state in which it is found in nature, bears a striking resemblance to barytes. There is also a striking analogy in the crystalline forms of the analogous species of each.

Sp. 1. *Green Carbonate of Strontian.*

Strontianite—peritomous hal-baryte of Mohs.

This species was first discovered in the galena vein at Strontian, in Argyleshire, and was recognised as a peculiar mineral species about the year 1791. It was not till about the year 1816 that it was observed in well defined crystals.



Colour asparagus green; structure radiated, and obviouslyexhibiting the rudiments of crystals (seemingly four-sided prisms) radiating from a centre. In the crystals the fracture is foliated.

The primary form of the crystal is a right rhombic prism.

M on M′ 117° 32′

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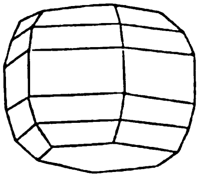
* Besides the species here enumerated, there are other three minerals which contain barytes. These are

1 Hormatome, $4AlS^3+BrS^2+6Aq$.
2 Brewsterite, $4AlS^3+(\frac{1}{3}Br+\frac{2}{3}Str)S^2+7Aq$.
3 Psilomelanite, composed of
{ 3 atoms subsesquihydrated binoxide of manganese,
{ 1 atom quadro-manganite of barytes.

These species will come under our consideration hereafter.

It differs from the primary form of carbonate of barytes by about 1 degree.

The crystals are small and rather uncommon. Hauy has given us the figure of a crystal found in England, (but he does not give the locality,) which is the primary form, having the edges G, G′ replaced by tangent planes. These additional faces occur in all the crystals hitherto observed, making the prism six-sided. The edges of the prism B are frequently replaced by single planes, and sometimes by two planes, constituting the figure in the margin. At Broundsdorf, near Freyberg, it occurs in acicular crystals. The large sized crystals have been found at Leogang, in Saltzburg.



Lustre shining, vitreous; translucent; hardness 3·5. The specific gravity of a very fine specimen I found 3·713.

Before the blowpipe it does not fuse, but is converted on the surface into an enamel which assumes a dazzling whiteness, and tinges the flame red. With borax or biphosphate of soda it fuses into a clear glass; with carbonate of soda into a glass which becomes opaque on cooling.

A careful analysis of the purest specimens to be had at Strontian, gave the constituents as follows:

		Atoms.
Carbonate of strontian, .	93·493 .	10·1
Carbonate of lime, . .	6.284 .	1·0
Carbonate of manganese, trace,	——	
Iron and alumina, . .	0·010	
	99·787	

This is obviously equivalent to

10 atoms carbonate of strontian,	92·5
1 atom carbonate of lime,	6·25
	98·75

Unless the green colour be owing to the trace of carbonate of manganese, which it contains, I do not know to what we are to ascribe it.

Sp. 2. *Brown Carbonate of Strontian.*

This mineral occurs in Strontian mine, along with the green carbonate, though it is rather less abundant. Doubtless it is to be found in other localities, though the descriptions given in mineralogical works are not sufficiently precise to enable us to point out any other place where it occurs. The acicular crystals found at Brounsdorf near Freyberg, as is obvious from the specific gravity, belong to this species.

Colour light yellowish brown.

Structure radiated, and obviously a congeries of prisms diverging from a centre. But these prisms are much smaller than those existing in the green carbonate, and they are much more easily detached from each other. Hence the specimens are very friable.

Translucent; lustre vitreous; specific gravity 3·651; hardness 3 to 3·5. It is scratched by green carbonate of strontian.

I found the constituents of a pure specimen

		Atoms.
Carbonate of strontian, .	91·082 .	9·845
——— lime, . .	8·642 .	1·382
——— manganese, .	0·099	
Oxide of iron and alumina, .	0·078	
	99·901	

This is very nearly

{ 7 atoms carbonate of strontian,
{ 1 atom carbonate of lime.

Sp. 3. *Sulphate of Strontian.*

Celestine, zölestine—prismatoidal halbaryte of Mohs.

This species was long confounded with sulphate of barytes, to which it bears a considerable resemblance. Its composition was first determined by the experiments of Klaproth and Vauquelin, who analyzed it, unknown to each other, about the year 1796. Werner gave it the name of *celestine*, from the blue colour which was at that time considered as characteristic of it; though since that period the same colour has been observed in sulphate of barytes. It was soon after discovered, in abundance, in the neighbourhood of Bristol, by Mr. Clayfield; and since that period it has been discovered in Germany and other countries, in very considerable deposites.

The colour is usually white, most frequently with a shade of sky blue; but sometimes with a shade of red or yellowish red.

It occurs most frequently crystallized, and then its fracture is foliated. The cross fracture is conchoidal. The primary form of its crystals, like that of sulphate of barytes, is a right rhombic prism. But the inclination of M on M′ is 104° instead of 101° 34′ as is the case with the prism of sulphate of barytes.

The modifications of this form in sulphate of strontian, are much the same as those in sulphate of barytes. The magnificent crystals from Sicily are elongated octahedrons, similar to that represented in page 104, making allowance for the difference in the measurement of the angles, which amounts to about 3°.

Lustre vitreous, inclining to pearly, and varying from shining to splendent. The impure compact variety, from the neighbourhood of Paris, has no lustre.

Sometimes transparent, sometimes only translucent. Refracts doubly.

Hardness 3 to 3·5. I found the specific gravity of a very fine and pure crystal from Sicily, 3·9626, and that of good translucent crystals from the neighbourhood of Bristol 3.9454.* According to Beudant the specific gravity varies from 3·9297 to 3·9593.*

Before the blowpipe it behaves very nearly as sulphate of barytes does, excepting the red tinge which it communicates to the flame when decomposed, and which characterizes sulphate of strontian.

When pure, it is composed of

1 atom sulphuric acid,	5
1 atom strontian,	6·5
	11·5

I analyzed very fine specimens from the neighbourhood of Bristol, and from Sicily, the result was as follows:

	Bristol.	Sicilian.
Sulphate of strontian, .	98·353 .	98·68
Sulphate of lime, .	1·073 .	1·02
Moisture, . . .	0·200 .	0·30
Foreign matter,† .	0·374	0
	100	100

It generally contains a little oxide of iron, and that of Bouvron, according to the analysis of M. Daurier, contains 27·795 per cent. of carbonate of lime. As Vauquelin, in another specimen from the same locality, found only 10 per cent. of carbonate of lime, it is clear, that this constituent is only accidental.*

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* Ann. des Mines (second series), v. 275.

† It was silica, with some alumina, and a trace of iron.

Sulphate of Strontian is found most commonly in the new red sandstone, which lies above the coal formation. Sometimes it is found in amygdaloid, connected with basalt, and at Mont Martre, near Paris, it occurs in the tertiary gypsum beds.

Sp. 4. *Baryto-Sulphate of Strontian.*

Radiated celestine.

This species is found in considerable quantity in Drummond island, in Lake Erie, and also at Kingstown, in Upper Canada.

The colour is white, with a very slight shade of blue.

The texture is laminated, and the laminæ, which are obviously imperfect crystals, diverge as if from a central point, so as to form a kind of pencil.

Brittle; very friable; hardness 2·75; specific gravity 3·921.

Before the blowpipe in the platinum forceps becomes of a dazzling white; but does not easily fuse. Melts readily with carbonate of soda into a transparent colourless bead, which becomes white and opaque on cooling. With borax it fuses very readily into a white opaque globule.

By an analysis of it made in my laboratory, its constituents were found to be

Sulphuric acid, . .	40·202
Barytes, . . .	23·059
Strontian, . . .	35·724
Protoxide of iron, . .	0·588
Water, . . .	0·720
	100·293

This is obviously equivalent to

		Atoms.	
Sulphate of barytes, .	35·195	2·42	3
Sulphate of strontian, .	63·204	5·49	7
Sulphate of iron, . .	1·241	0·13	
Water, ...	0·720		
	100·360		

Omitting the small quantity of sulphate of iron as accidental, the mineral is a compound of

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* Ann. de Chim. et de Phys., xlvi. 312

$\left\{\begin{array}{l}\text{3 atoms sulphate of barytes,}\\ \text{7 atoms sulphate of strontian.}\end{array}\right.$

Sulphates of barytes and of strontian occur native combined in other proportions, and constituting therefore other species which have not yet been accurately described. Thus the mineral found at Nörten, in Hanover, and known by the name of radiated Celestine, is a compound, according to the analysis of Dr. Turner, of

Sulphate of barytes, . .	20·41
Sulphate of strontian, . .	78·205
	98·615[*]

This is very nearly

$\left\{\begin{array}{l}\text{1 atom sulphate of barytes,}\\ \text{5 atoms sulphate of strontian.}\end{array}\right.$[†]

Sp. 5. *Calcareo-Sulphate of Strontian.*

I have a specimen of this mineral in my cabinet; but I am unacquainted with its locality; though I suspect that it came from the neighbourhood of Bristol.

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[*] Edinburgh Phil. Jour., ii. 329.

[†] A remarkable variety of this mineral occurs at Nörten, about six miles from Hanover, constituting thin beds in a limestone, probably connected with the oolite formation. It is partly in crystals, and partly in a weathered and friable state. There are three thin beds; in the first the mineral is crystallized, in the two others it is in a weathered and friable state.

The crystals have a silky lustre, and a milk-white colour, here and there passing into blue. The specific gravity, as determined by Gruner, is 3·9506.[*]

These crystals analyzed by Mine Commissioner Gruner of Hanover gave

Ferruginous alumina, . .	0·213
Sulphate of strontian, . .	73·000, or 7 atoms
Sulphate of barytes, . .	26·166, or 2 atoms
	99·379[‡]

The weathered portion from the third bed was found to be composed of

Alumina, ...	1·00
Sulphate of strontian, . .	24·00, or 2 atoms
Sulphate of barytes, . .	74·66, or 5 atoms
	99·66[‡‡]

I have not seen any accurate description of these minerals, but I have little doubt that they will constitute two new species. The first, indeed, is intimately connected with the baryto-sulphate of strontian species from America, if it be not identical with it; but the second seems new.

[*] The specific gravity is stated in the paper at 3.5906; but I take it for granted that the 5 and 9 have accidentally changed places.

[‡] Gilbert's Annalen, lx. 72.

[‡‡] Ibid. p. 77.

The colour is white with a shade of red. It is composed of small thin plates, or radii, which are interlaced; lustre silky. The single plates are transparent, and the mass is translucent on the edges; very easily frangible; hardness 2·75; scratched by carbonate of strontian; specific gravity 3·81.

Before the blowpipe behaves nearly as sulphate of strontian.

Its constituents, by the analysis of Dr. Jephson of Leamington, were

		Atoms.
Sulphuric acid, .	45·928	9·1856
Lime, . . .	7·160	2·045
Strontian, . . .	46·888	7·25
	99·976	

It is therefore a compound of

{ 2 atoms sulphate of lime,
{ 7 atoms sulphate of strontian.

Sp. 6. *Stromnite.*

This mineral was observed at Stromness, in the Orkneys, by Dr. Trail, in the year 1803. In the year 1817, he analyzed it, and an account of it was read before the Royal Society of Edinburgh, which was published in the ninth volume of the Edinburgh Philosophical Transactions. It occurs in masses, in a kind of slate, connected with an abandoned lead mine.

The colour is greyish-white, passing into pale yellowish-white. The lustre is shining, and pearly in the principal fracture, glistening and resinous in the cross fracture.

The mineral is radiated, or composed of small plates, or radii, somewhat diverging.

Translucent when in thin fragments; specific gravity 3·903; hardness 3·5; rather brittle and easily frangible.

It is infusible per se before the blowpipe.

Its constituents, as determined by the analysis of Dr. Trail are,

Carbonate of strontian, . .	68·6
Sulphate of barytes, . . .	27·5
Carbonate of lime, . . .	2·6
Oxide of iron, ...	0·1
	98·8*

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* Edinr. Trans. vol. ix. p. 81.

If this mineral constitute a chemical compound, it is certainly a very extraordinary one. The preceding numbers approach

4 atoms carbonate of strontian,
1 atom sulphate of barytes,
¼th atom carbonate of lime.

But perhaps the carbonate of lime should be considered only as accidental. What renders it probable, that the constituents of this mineral are chemically combined, is, that the specific gravity is less than the mean. For the mean specific gravity is 3·81 instead of 3·703, which Dr. Trail obtained.

GENUS VII.—CALCIUM.

Calcium, like barium and strontium, is never found near the surface of the earth in the metallic state; but always united to oxygen and converted into lime. Even lime has so strong an affinity for acids, that it exists only in a state of combination with acids. Lime is much more abundant in the mineral kingdom than barytes, or strontian. It occurs most commonly united to carbonic acid constituting limestone, which form whole mountains, or even ranges of mountains. It is met with likewise in considerable quantity combined with sulphuric and fluoric acid, nor is it rare in combination with phosphoric acid. It is found also united to silica, to arsenic acid, tungstic, boracic, and titanic acids; but not so abundantly. The number of species belonging to this genus at present known, amount to 30. Of these 13 are simple salts, 15 double salts, and 2 triple salts, or more probably salts of a still more complex nature.

A. SIMPLE SALTS.

Sp. 1. *Calcareous Spar.*

Agaric mineral, anthraconite, aphrite,* argentine, chalk, inolite, limestone, lumachella, madreporite, marble, marl, oolite, ostreocolla, peastone, pisolite, slate spar, schiefer spar, travertine, tufa.

This species is very abundantly scattered through the mineral kingdom, constituting whole ranges of mountains, or existing in the state of beds alternating with other rocks. But calcareous spar, which alone possesses the complete characters of the species, is met with only in veins or cavities in other rocks.

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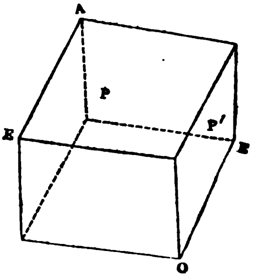
* The term *aphrite* has been also applied to the tourmalin. See Mohs, ii, 349.

The colour of pure calcareous spar is snow-white; but the mineral is frequently tinged yellow, grey, red, or even green, and some varieties are nearly black.



The fracture is foliated, and the cleavage is parallel to the faces of an obtuse rhomboid, in which the faces P, P′ are inclined to each other at an angle of 105° 5′. This constitutes the primary form of the mineral, which occurs very frequently in the mineral kingdom. But calcareous spar is met with crystallized in a greater variety of forms than any other mineral hitherto known. Count Bournon in his *Traité de Mineralogie* has engraven figures of no fewer than 680 modifications; and Hauy, in the second edition of his Mineralogy, has given figures and descriptions of 155 different modifications. These crystalline shapes may be referred to rhomboids, prisms, and pyramids. When the angle of the summit A is replaced by three or six planes resting on the primary planes or edges of the crystal, and when these replacements increase so much as to obliterate the primary faces of the crystal, they occasion three-sided or six-sided pyramids. These being double, and applied base to base, the three-sided pyramids constituted long and acute rhomboids; while the six-sided pyramids constitute pyramidal dodecahedrons. When the lateral solid angles are replaced by planes parallel to the perpendicular axis of the rhomboid regular six-sided prisms are formed, which is the most common shape of the crystals of calcareous spar found in Derbyshire; while the pyramidal dodecahedron characterizes the calcareous spar of strontian.

When each lateral solid angle of the rhomboid is replaced by two planes meeting at an edge which is parallel to the perpendicular axis, twelve-sided prisms are formed. When only the alternate lateral angle is replaced by a plane parallel to the perpendicular axis, a three-sided prism is formed. This figure is uncommon; but occurs in a quarry not far from Kirkaldy, in the County of Fife.

Various other modifications are produced by the superior edges of the rhomboid being replaced by tangent plane, or by two planes; or by the lateral edges being replaced by tangent planes, or by two planes. The first produces a rhomboid more obtuse than the primary; the second produces pyramidal dodecahedrons, whose faces are usually isosceles triangles; the third produces a regular six-sided prism; and the fourth pyramidal dodecahedrons, whose faces are generally scalene triangles.

The lustre of calcareous spar, when the mineral is pure, is splendent and vitreous. It is transparent, and refracts doubly very powerfully, doubling an image viewed through parallel faces of the crystal.

Hardness 3; specific gravity when pure 2·721. Haidinger has given us the specific gravity of a variety of specimens more or less pure tried by him. The lowest was 2·508, and the highest 2·778;* but neither of these two extremes exhibits the mineral in a state of purity. According to Beudant, the specific gravity of Iceland crystal (the purest kind of calcareous spar) varies from 2·5239 to 2·7234.†

Before the blowpipe, on charcoal, it becomes caustic lime, and then shines with peculiar lustre. With borax, or with biphosphate of soda, it fuses with effervescence into a glass. With soda it does not fuse, nor enter into combination.

When pure, it is composed of

1 atom carbonic acid, .	2·75
1 atom lime, . . .	3·5
	6·25

But it is very rarely free from some slight admixture of foreign matter.

It occurs in veins in every kind of rock, from the oldest to the newest.

Limestone, chalk, marble, &c., consist of the same materials as calcareous spar, but not crystallized, and therefore not constituting proper mineral species. The property which all these minerals have of dissolving with effervescence in muriatic acid, while the neutral solution is thrown down white by oxalate of ammonia characterizes all the varieties of carbonate of lime.

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* Annals of Philosophy (second series), ix. 392.

† Ann. des Mines (second series), v. 275.

Sp. 2. *Arragonite.*

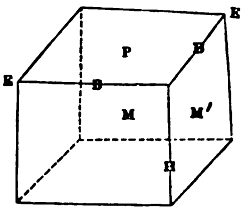
Igloite—flos ferri—needle spar.

This mineral was for some time confounded with the preceding; but it was rightly constituted a peculiar species by Werner, because its hardness, specific gravity, and crystalline form are peculiar. He gave it the name of Arragonite, because the first specimens came from Arragon, in Spain.

The most common colour of arragonite is white; but frequently it has a shade of blue, or yellow, and sometimes of grey, or even green.

The structure is foliated with a threefold cleavage. In the stalactitical variety, called *flos ferri,*[*] the structure is usually fibrous, and the fibres run in a longitudinal direction.

The primary form of the crystal is a right rhomboidal prism, in which M on M′ is 116° 10′, according to the measurement of Mr. Brooke, and 116° 5′, according to the measurement of Mr. Phillips.



Three of these crystals are frequently grouped together in such a manner as to constitute a six-sided prism. The two acute angles of the prism are sometimes replaced by two faces, which conceal the base P, and convert the crystal into a very elongated octahedron. Sometimes the edges B are replaced by tangent planes, which occasionally become very large. The edge H is at the same time replaced by a tangent plane. In consequence of this the crystal terminates in a long six-sided pyramid, the extremity of which is not a point, but a ridge. A good account of the crystalline forms of the arragonite is given by Bournon.[†]

The lustre is glassy. The mineral is sometimes only translucent, sometimes transparent. It refracts doubly, but not nearly so much so as calcareous spar.

Hardness 3·75; specific gravity, as determined by Haidinger, 2·931;[‡] by Bournon, 2·920;[§] by Biot, 2·9267.[||] Stromeyer found the specific gravity of different specimens, from

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[*] *Flos ferri* was considered by the older mineralogists as an ore of iron, Hauy first showed that it was a variety of arragonite.

[†] Traité de Mineralogie, ii. 119.

[‡] Annals of Philosophy (second series), ix. 392.

[§] Traité de Mineralogie, ii. 120.

[||] Mem. d'Arcueil. ii. 202.

2·9304 to 2·885.* According to Beudant, it varies from 2·7647 to 2·9467.†

The action of the blowpipe on arragonite, is precisely similar to that on calcareous spar.

Arragonite, like calcareous spar, is essentially a carbonate of lime. Stromeyer discovered that it contained also carbonate of strontian, which varies in quantity in different specimens from 4·1 per cent. to 0·5 per cent.; those specimens which have the highest specific gravity containing the greatest quantity, and *vice versa*. Arragonite contains also some water, which varies from 0·6 per cent. to 0·154 per cent. Those specimens which contain the most carbonate of strontian, in general containing also the most water. Whether the carbonate of strontian is in chemical combination with the carbonate of lime, is not clear. The specimens containing the most of the strontian, consist of

35 atoms carbonate of lime,
1 atom carbonate of strontian,
$1\frac{1}{5}$ atom water.

While the specimens containing the least, are composed of

288 atoms carbonate of lime,
1 atom carbonate of strontian,
3 atoms water.

Stromeyer ascribes the peculiar crystalline form of arragonite to the carbonate of strontian which it contains. The primary forms of the two minerals do not differ more from each other than 1° 22′; but as this difference is constant, it indicates two distinct species. The presence of water in arragonite was first observed by Mr. Holme. When arragonite is heated it falls to powder and loses its water. This readily distinguishes it from calcareous spar.

It was first found embedded in gypsum. It occurs in cavities and veins in basalt and other trap rocks. Fine specimens of it are met with at Leadhills in Lanarkshire, in veins traversing transition rocks.

Sp. 3. *Subsesquicarbonate of Lime.*

Blue Vesuvian limestone.

This species is found in loose masses among ejected minerals in the neighbourhood of Vesuvius. It was described by Karsten and analyzed by Klaproth‡ in 1807.

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* Untersuchungen, p. 74, &c. † Ann. des Mines (2d series), v. 275.

‡ Beitrage, v. 91.

Its colour is dark bluish grey partly veined with white. Externally it appears as if it had been rolled. Surface uneven; fracture fine grained earthy, passing into splintery; opaque; streak white; semihard in a low degree; not particularly heavy.* Its constituents as determined by Klaproth, are

Lime, ...	58
Carbonic acid, . . .	28·5
Water, slightly ammoniacal,	11
Magnesia, . . .	0·5
Oxide of iron, . . .	0·25
Charcoal, . . .	0·25
Silica, ...	1·25
	99·75

These numbers (supposing them exact) are equivalent to

1·595 atom lime,
1 atom carbonic acid,
0·94 atom water,
0·015 atom magnesia,
0·05 atom silica.

If we leave out the magnesia and silica, which are in so small quantity as not much to affect the chemical constitution of the mineral, the constituents seem to be

$1\frac{1}{2}$ atom lime,
1 atom carbonic acid,
1 atom water.

It is therefore a hydrous subsesquicarbonate of lime.

Sp. 4. *Hydrous Sulphate of Lime.*

Alabaster, gypsum,† selenite.

This mineral, so useful under the name of *plaster*, is very abundant, occurring in beds chiefly in the new red sandstone, though it is found also in other situations, particularly in the neighbourhood of Paris where it lies over the chalk. Very fine specimens are met with in Shotover hill near Oxford, and at Carrickfergus in the County of Antrim.

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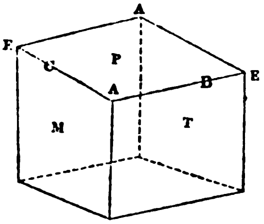
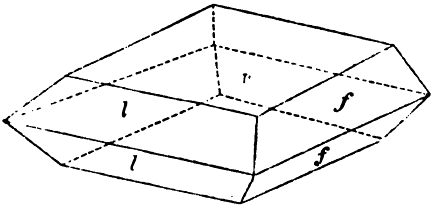
* The description given is that of Karsten. I have not myself seen this mineral.

† The term γυψος (*gypsum*) was used by the Greeks, at least as early as the time of Theophrastus. Gypsum was applied by the ancients to the same uses that we apply it; but they were ignorant of its composition. One of the earliest of the analytical attempts of Lavoisier was to analyze it (1768). He determined the nature of the constituents but not their proportions. Margraaff had already made the same discovery in 1750.

The colour of this mineral when pure, is snow-white; but it occurs often red, yellow, blue, and grey.

When crystallized it is foliated; but it is found also fibrous, granular, and compact. The foliated varieties are called *selenite* from their fine white colour. They split into thin leaves parallel to the base of a right oblique prism, the faces of which, as determined by Hauy, are inclined to each other at angles of 113° 8′, and 66° 52′. And this determination has been conrfimed by subsequent measurements with the reflecting goniometer. Sometimes the solid angles A or E, are replaced by tangent planes, and sometimes the lateral edges, B, C are replaced by tangent planes. These replacements occasion the different varieties in the crystalline forms observed. The replacement of the edges constitutes the most common form observed. It is represented in the margin, where P represents the base of the primary prism, and *l*, *l*, and *f*, *f*, the new faces produced by replacing the lateral edges of the prism.





Hemitrope crystals of this mineral are very common.*

Lustre of the lateral faces of the prism and of those by replacement, vitreous; that of the base of the prism is pearly, and this face is usually streaked.

It varies from translucent to transparent. The transparent varieties refract doubly, when an object is viewed through two oblique faces.

Hardness 2; easily scratched by the nail. This renders ornaments of alabaster very easily soiled and injured.

Specific gravity of a transparent, white crystal from Oxford, as determined by Hisinger, 2·310.† According to Beudant, the specific gravity of this mineral varies from 2·3121 to 2·3257.*

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* By *hemitrope* is meant a figure produced by cutting the primary crystal in two, causing one of the fragments to make half a revolution, and then uniting the sides actually in contact.

† Annals of Philosophy (2d series), ix. 391.

When the *faces* of a fragment are heated before the blowpipe it does not fuse; but when the *edges* are exposed to the flame, the layers gradually separate and fuse into an enamel. In a few hours the bead falls spontaneously to powder. When heated with fluor spar, it easily undergoes fusion.

The constituents of this mineral are

1 atom sulphuric acid, .	5
1 atom lime, . . .	3·5
2 atoms water, . . .	2·25
	10·75

When heated the water is easily driven off. When the anhydrous powder is mixed with water, it forms a liquid paste which easily attaches itself to the inside of a mould, and in a few minutes becomes solid. In this way it is used to make casts of statues, &c. To fit it for this purpose, it must be mixed with about a third of its weight of lime. What is called *Plaster of Paris* constitutes such a native mixture. It is so called because it occurs in that state in the gypsum quarries round Paris.

The new red sandstone formation, as has been already stated, constitutes the great deposite of this mineral. But it occurs also in other situations. Thus, it is found occasionally in the coal beds, and indeed occurs in small quantities in most of the secondary formations. In Germany it abounds; but in England it is, comparatively speaking, scanty in the new red sandstone.

Sp. 5. *Anhydrous Sulphate of Lime.*

Anhydrite, karstenite, muriacite, cube spar, pierre de trippes, gekrösstein.

This mineral seems to have been first noticed by the Abbé Poda, who gave it the name of *muriacite*, probably from the common salt with which it is often associated. Fichtel gave an account of it in 1794; but it was Hauy who first determined its characters and described it with accuracy. The crystalline shape was first determined by Bournon.†

The colour of the pure mineral is white; but it has very frequently a flesh red, grey, or light blue colour.

The fracture is imperfect conchoidal; the crystals are always foliated, but some of the compact varieties are granular.

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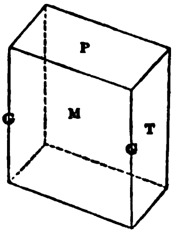
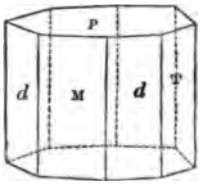
* Ann. des Mines (2d series), v. 275.

† Jour. des Mines, xiii. 345.





The primary form of the crystal is a right rectangular prism. Pretty frequently the lateral edges of the prism G are replaced by planes, which converts the primary form into the octahedral prism represented in the margin. The faces *d*, make with the face T an angle of 129° 56′, and with the face M an angle of 140° 4′.

The lustre is vitreous, inclining to pearly, upon the most distinct cleavage planes.

Translucent, sometimes nearly transparent. It refracts doubly very powerfully, when an object is viewed through two faces oblique to each other.

The specific gravity, as determined by Haidinger, is 2·899.* Bournon found that of a crystal 2·940. It was not quite free from common salt. The purest specimen tried had a specific gravity of 2·957: that of another crystal was 2·929.† Hardness from 2·75 to 3, or even 3·25.

Before the blowpipe it behaves like the preceding species, except that it gives out no water.

Its constituents, when pure, are

1 atom sulphuric acid,	5
1 atom lime, . .	3·5
	8·5

But it very frequently contains a little common salt, the maximum of which rarely exceeds 1 per cent.

Crystals of this mineral are occasionally met with which have absorbed water, and so are converted into common hydrous sulphate; yet they retain their original shape. A variety of this kind, of a fine blue colour, from a trap dyke at the base of the Cave Hill, near Belfast, had a specific gravity of 2·905, and consisted of

Carbonate of lime,	63·12
Sulphate of lime, .	32·84
Water, . . .	3·60
	99·56

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* Annals of Philosophy (second series), ix. 391.

† Jour. des Mines, xiii. 350.

This is equivalent to

$2\frac{1}{2}$ atoms carbonate of lime,
1 atom sulphate of lime,
$\frac{4}{5}$ atom of water.

If we consider the water as united to the sulphate, it will follow that it has absorbed nearly half the water which exists in hydrous sulphate of lime. But from the great increase in the specific gravity, it is probable that the carbonate and sulphate of lime in this mineral are in chemical combination. If we leave out of view the water altogether, the specific gravity of a mixture of 63·12 carbonate of lime, and 32·84 sulphate of lime, would be only 2·708; and if we take the water into account, and suppose it only mechanically mixed, that specific gravity would be reduced to 2·646. Even if we suppose the water to be absorbed by the mineral without any increase of its bulk, the specific gravity would only be 2·745. All these numbers are so much below 2·905, that we cannot avoid admitting a chemical combination between the constituents, and a contraction in consequence.

Anhydrous sulphate of lime occurs along with the preceding species; but it is much less abundant, and never constitutes extensive beds.

Sp. 6. *Siliceous Sulphate of Lime.*

Vulpenite, bordiglione.

This mineral, which occurs at Vulpino, in Italy, has been generally considered as a mechanical mixture of anhydrous sulphate of lime and silica; but neither its hardness nor its specific gravity is reconcileable with that supposition.

Colour greyish white, and veined with bluish grey. The mineral is foliated, and it is said to exhibit a threefold slightly oblique cleavage, indicating for the primary crystal a right four-sided prism, slightly oblique.

Internal lustre splendent; translucent on the edges; specific gravity 2·8787, as determined by Hauy;* hardness 2·75.

Fuses readily before the blowpipe into an opaque white enamel.

Its constituents, according to the analysis of Vauquelin, are

Sulphate of lime, .	89·76
Silica, . . .	8
	97·76†

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* Mineralogie (first edition), iv. 353.

† Jour. des Mines, vi. 808. The sulphate of lime is corrected.

This corresponds with

$2\frac{5}{8}$ atoms sulphate of lime,
1 atom silica.

If the loss (as is probable) be sulphate of lime, the constituents will be

$2\frac{3}{4}$ atoms sulphate of lime,
1 atom silica.

Both of these ratios are rather improbable.

This mineral is cut and polished in Italy, and applied to various ornamental purposes.

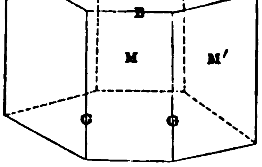
Sp. 7. *Subsesquiphosphate of Lime.*[*]

Apatite, asparagus stone, moroxite, phosphorite.

This mineral, which occurs pretty commonly in translucent crystals, having the form of a six-sided prism, and pretty frequently a blue colour, was considered by Romé de Lisle as a *gem*. When the prism was terminated by a six-sided pyramid he called it *chrysolite*, when by a hexahedral face he considered it as a variety of *emerald*. In the year 1788, Klaproth discovered that it was a compound of phosphoric acid and lime; and Werner gave it the name of *apatite*, on account of the variety of mistaken opinions which had been embraced respecting it by mineralogists.[†] The asparagus green variety he afterwards distinguished by the name of *spargelstein*.

The colour of apatite is sometimes white, but much more frequently violet blue; often green; sometimes yellow, grey, red, and even brown. The colours are never bright.

The mineral is always foliated, and the cleavage, which is not very perfect, is parallel to the faces and base of the regular six-sided prism. This is the most common form of the crystal. Sometimes the terminal edges B, B, &c., are replaced by tangent planes, which causes the prism to terminate in a six-sided pyramid. A similar six-sided pyramid is produced when the solid angles of the prism are replaced by planes. Sometimes the lateral edges of the prism are replaced by tangent planes, or by two planes. The first changes the prism into one with twelve sides, and the second into one with eighteen sides. Of this last crystal



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[*] Called by the French jewellers *chrysolite*.

[†] See Bergmannische Jour. 1788, i. 76, &c.

I have never seen a specimen, but the replacements on the angles and edges often occur together.

Cross fracture conchoidal; apatite is usually translucent, but seldom transparent. Refracts singly; hardness 5.

The specific gravity of asparagus green crystals, from Spain, was found by Haidinger to be 3·225, and that of green transparent crystals from Saltzburg 3·180.* According to Hauy the specific gravity varies from 3·0989 to 3·2.† G. Rose found the specific gravity of different specimens to vary from 3·166 to 3·235.‡

Before the blowpipe it remains unaltered, unless the flame be directed against the edges of the fragment, when it fuses with difficulty into an enamel. With borax or biphosphate of soda it melts easily into a glass. It fuses also when mixed with carbonate of iron.

The phosphoric acid and lime in this mineral are combined in the proportion of 1 atom acid to $1\frac{1}{2}$ atom lime, as is evident from the analysis of Klaproth, who obtained

Phosphoric acid, .	4·572
Lime, . . .	5·428
	10·000§

Now an atom of phosphoric acid weighs 4·5, and $1\frac{1}{2}$ atom of lime 5·25. There is a small excess of lime; but G. Rose has shown that the mineral always contains fluoric acid and chlorine, both of which are in combination with lime or calcium. The following table exhibits the result of his analysis of seven different specimens of apatite, from different localities.

Locality.	Chloride of Calcium.	Fluoride of Calcium.	Subsesqui-phosphate of lime.	Specific gravity.
Snorum, Norway,	4·28	4·59	91·13	3·174
Cubo de Gata, Spain,	0·885	7·049	92·066	3·235
Arendal, Norway,	0·801	7·01	92·189	3·194
Greiner, Tyrol,	0·150	7·69	92·160	3·175
Faldigt, Tyrol,	0·1	7·62	92·28	3·166
St. Gothard, Alps,	Trace	7·69	92·31	3·197
Ehrenfriedsdorf, Germany,	Trace	7·69	92·31	13·21

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* Annals of Philosophy (second series), ix. 391.

† Mineralogie, i. 488.

‡ Poggendorf's Annalen, ix. 185.

§ Beitrage, iv. 194.

If we take the chloride of calcium and fluoride of calcium together, the mineral will be composed of

1 atom chloride and fluoride of calcium,
6 atoms subsesquiphosphate of lime.

Subsesquiphosphate of lime is not unfrequently mixed with the carbonate of iron, which is so abundant in the coal beds; though in a state of purity it is very rarely found in that situation. But at Fins, in France, it has been observed in shale in small spherical nodules, sometimes flattened, and enveloped in carbonate of iron. A specimen of this mineral, analyzed by M. Jules Guillemin, and having a specific gravity of 2·65, was composed of

Subsesquiphosphate of lime,	86·3
Carbonate of iron,	11·7
Alumina,	0·6
Coal and water,	1·4
	100·0

Another specimen yielded M. Berthier

Subsesquiphosphate of lime,	67·0
Carbonate of iron,	15·7
Alumina,	9·0
Water and bitumen,	6·0
	97·7*

From the great variation in the proportions in these two specimens, it is obvious that the apatite and carbonate of iron are only mechanically mixed.

Apatite occurs usually in primary formations; sometimes it forms a constituent of granite, but very rarely. It is often met with in veins, particularly along with tin and iron ore. It exists in the talky looking substance which accompanies the tinstone in some of the Cornish mines, and which I have distinguished by the name of *Gilbertite*. It is found also in the serpentine of Portsoy. The phosphorite, which constitutes a rock, exists in beds in Estremadura, in Spain, and Schlockenwald, in Bohemia.

Sp. 8. *Fluor Spar.*

Fluate of lime, fluoride of calcium, ratoffkit, chlorophane.

This mineral is abundant, and very interesting on account of the beauty of its colours, and the perfection and variety of its crystalline forms. It is alluded to by Theophrastus, and pretty minutely described by Agricola, in his *Bermannus*, under the name of *fluor*.

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* Memoires de Berthier, i. 138.

Fluor spar is sometimes transparent and colourless; but much more frequently it is tinged of some colour or other. Yellow and violet blue are two of the most common colours; sometimes it is green of different shades, and more rarely rose red or crimson red.

When crystallized the texture is always foliated, but that of the compact varieties is granular; fracture conchoidal.

The primary form of the crystal is the regular octahedron; but in general the solid angles are replaced by tangent planes, which change the figure into the cube. Both of these sets of faces occur, sometimes together, constituting the cubo-octahedron; sometimes the edges of the octahedron are replaced by tangent planes. When these increase so as to conceal the primary faces, the *garnet* or *rhomboidal* dodecahedron is produced. Sometimes the solid angles are replaced by three planes, which produces the 24 sided figure, known by the name of *leucite crystal*, (see *leucite*); and sometimes the solid angles are replaced by six planes, which constitutes a crystal nearly spherical, and bounded by 48 faces. These different replacements are frequently combined together in the same crystal, which renders the figure pretty complex. One crystal figured by Mr. Phillips had no fewer than 322 faces.*

The lustre is vitreous; varies from transparent to translucent; hardness 4. The specific gravity, as determined by Haidinger, varies from 3·140 to 3·178.† Hauy states it to vary from 3·0943 to 3·1911.

Before the blowpipe the mineral decrepitates and at last fuses into an enamel. If the flame be continued, the fluoric acid is partly expelled, and the assay assumes a cauliflower appearance.

Two views may be taken of the composition of fluor spar. It may be considered as a compound of

1 atom fluoric acid, . .	1·25
1 atom lime, . . .	3·5
	4·75
Or of 1 atom fluorine, . . .	2·25
1 atom calcium, . . .	2·5
	4·75

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* Mineralogy, p. 170. † Annals of Philosophy (2d series), ix. 391.

The last of these views is the one at present most generally adopted by chemists.

Fluor spar is very rarely met with in a state of purity. It is generally mixed with silica, the presence of which cannot be detected except by digesting the pounded mineral with sulphuric acid. If silica be present, fluosilicic acid gas is driven off, easily recognised by its odour, and its depositing silica when passed through water.

Fluor spar occurs but seldom in rocks, and is still more rarely met with in beds. In a trap rock at Gourock, on the Frith of Clyde, small yellow cubes of it are occasionally observed. It is met with in a similar rock at Papa Stour, one of the Shetland islands. In Ireland it occurs in cavities in the granite of the Dalkey coast. It is much more abundant in veins, and very commonly accompanies the ores of lead, particularly galena. Hence its great abundance in the north of England, where it constitutes the gangue of the lead veins which intersect the coal formations of Northumberland, Cumberland, Durham, and Yorkshire. In Derbyshire it is very abundant, and by no means uncommon in Cornwall, where the veins traverse much older rocks. In the mining districts of Saxony, &c., it is very abundant.

Most of the varieties of fluor spar phosphoresce when heated; but there is a great variety both in the colour of the light transmitted, and in its intensity.

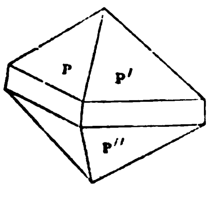
Sp. 9. *Sesquisilicate of Lime.*

Zeagonite, abrazite, gismodin.

This mineral occurs in the drusy cavities of a volcanic rock at Capo di Bove, near Rome. It was first noticed by Gismondi. Breislak has given an imperfect description of it, with which I must satisfy myself here, as I have never had an opportunity of examining the mineral.

Colour pale smalt blue; sometimes white or grey, and sometimes rose red.

The fracture is conchoidal. It is always crystallized, and the crystals are octahedrons, with a square base. The figure in the margin represents a crystal in possession of Mr. Brooke, who has determined the angles as follows:



P on P′ 122° 58′.

P′ on P″ 85° 40′.

Lustre adamantine; translucent, and

when in small crystals, transparent; hardness 7 to 7·5; specific gravity not given.

Before the blowpipe it phosphoresces and becomes friable, but does not fuse.

According to the analysis of Carpi, its constituents are,

Silica, . . .	41·4
Lime, . . .	48·6
Alumina, . .	2·5
Magnesia, . .	1·5
Oxide of iron, . .	2·5
	96·5

If we admit that no alkali is present, and that the alumina, magnesia, and oxide of iron, are not essential constituents, then the mineral will be a compound of

Silica, . . .	1·491 atom,
Lime, . . .	1 atom.

This is very nearly

1½ atom silica,
1 atom lime.

It is not unlikely from this that it may be a sesquisilicate of lime; but a more accurate analysis would be requisite, in order to establish its chemical constitution in a satisfactory manner.

Sp. 10. *Bisilicate of Lime.*

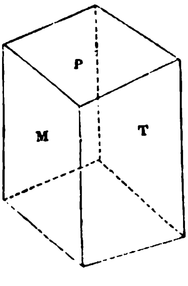
Table spar, schaalstein, grammite, wollastonite of Hauy.

This mineral was first found by Stütz, at Dograzka, in the Bannat of Temeswar, and called by him *table spar*, about the year 1793. Its nature was first determined by the analysis of Klaproth, which appeared in the third volume of his *Beitrage*, in 1802.

The colour of this mineral is white, with a shade of grey, yellow, red, or brown. The streak is white.

Structure foliated, with a single distinct cleavage. It yields by mechanical division a doubly oblique prism, in which, according to the measurement of Brooke,

P on M 126°
P on T 93° 40′
M on T 95° 15′



The lustre is vitreous, inclining to pearly; semitransparent; sometimes only translucent on the edges.

Hardness 3 to 4.

Haidinger found the specific gravity of a brownish white specimen from the Bannat 2·805. I found the specific gravity of different specimens from Rhode Island to vary from 2·785 to 2·895. Karsten states the specific gravity at 2·863.

Before the blowpipe it melts with difficulty into a semi-transparent colourless glass; with borax it fuses easily into a transparent glass.

We have a great many analyses of this mineral, all of which concur to show that it is a compound of 2 atoms silica, and 1 atom lime, but never free from small quantities of foreign matter. The following table exhibits the most accurate of these analyses:

	Per me	*	†	‡	§	Per me.	‖	¶
Silica,	49·56	50	51	51·445	51·6	51·716	52·58	53·1
Lime,	45·52	45·9	46	47·412	46·41	43·352	44·45	45·1
Protox. of iron,	3·00	—	1·3	0·401	trace,	1·908	1·13	—
Protox. of mangan.,	—	—	—	·257	—	—	—	—
Magnesia,	—	—	—	—	—	—	0·68	1·8
Water,	1·44	5	1	0·076	—	3·20	0·99	—
Actinolite,	—	—	—	—	1·11	—	—	—
	99·52	100·9	99·3	99·591	99·12	100·176	99·83	100

The mean of these analyses gives us

1·964 atom silica,
1 atom lime.

This comes exceedingly near 2 atoms silica and 1 atom lime, showing that the mineral is a bisilicate. Doubtless the slight error is owing to the presence of small portions of foreign matter.

It occurs most commonly in limestone, both primary and secondary. It is a constituent of the cinnamonstone rock from Ceylon, and is found in a state of great purity in Rhode Island, near New York. The specimens of it said to be found in the Castle rock at Edinburgh, proved, when analyzed in my laboratory, to be prehnite.

Sp. 11. *Wollastonite.*

Hauy gave the name of *Wollastonite* to the preceding spe-

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[*] Klaproth, Beitrage, iii. 289. [†] Seybert, Ann. des Mines, ix. 399.

[‡] Stromeyer, Untersuchungen, i. 356.

[§] Nordenskiöld's Bidrag, p. 94.

[‖] Bonsdorf, Annals of Philosophy (second series), ii. 300.

[¶] Beudant, Ann. des Mines (second series), v. 305.

cies; but as that mineral had been long known and already distinguished by the name of *table spar*, there was no great probability of mineralogists in general adopting this designation. The benefits conferred upon mineralogy by the late Dr. Wollaston were of no ordinary kind, and rendered it exceedingly desirable that some well characterized mineral species should be distinguished by his name. This was the reason which led me to give the appellation *Wollastonite* to the present species, which occurs in considerable quantity in veins in a greenstone rock, situated near Kilsyth, and not far from the banks of the Forth and Clyde Canal. It has also been discovered by Lord Greenock in the neighbourhood of Edinburgh. It is related to *table spar*, being in fact a compound of 4 atoms of that mineral with 1 atom of tersilicate of soda.

The colour of Wollastonite is white, with a slight shade of green.

The texture is fibrous, and the fibres are in tufts, diverging from a centre. This structure shows that the mineral is imperfectly crystallized.

Lustre inclining to silky; translucent on the edges; fracture splintery; fragments sharp edged; hardness 2·5.

Specific gravity varies in different specimens from 2·850 to 2·876.

Before the blowpipe it fuses with some difficulty, and without frothing into a white enamel. With borax it fuses into a bead, which is yellow while hot, but becomes colourless when cold. With biphosphate of soda in considerable excess it melts into a colourless bead, leaving a silica skeleton. With carbonate of soda it froths, and forms an opaque bead, having a shade of reddish blue.

Its constituents were found to be

		Atoms.
Silica,	52·744	26·37
Lime,	31·684	9·05
Soda,	9·600	2·4
Magnesia,	1·520	0·6
Protoxide of iron,	1·200	0·24
Alumina,	0·672	0·3
Water,	2·000	1·77
	99·420	

If we reckon the magnesia along with the lime, and neglect the protoxide of iron and alumina, as only accidental ingredients, it is evident that Wollastonite is a compound of

4 atoms bisilicate of lime,
1 atom tersilicate of soda.

The water being less than an atom is probably only mechanically lodged in the interstices of the fibres. The formula exhibiting its composition is $4CalS^2+NS^3$.

Sp. 12. *Tersilicate of Lime.*

This mineral was first noticed by Hisinger, in 1823. It is found at Gjellebäk, four Swedish miles south from Christiania, in Norway, in a transition limestone which extends some way south along the coast. It had from its appearance been mistaken for a tremolite, till Hisinger subjected it to analysis, and recognised its true nature.* There is in my cabinet a specimen of a mineral whose constituents are similar to those of the Gjellebäk mineral, but I do not know its locality. It is from this specimen that I have drawn up the following description and analysis; for Hisinger's specimen was obviously less pure than mine.

The colour of this mineral is snow-white. Hisinger says that by exposure to the air it becomes grey; but my specimen, which I have had about 20 years, is still snow-white.

The texture is fine radiated, which gives it a good deal of the aspect of *tremolite.*

It phosphoresces strongly when rubbed or struck; but only slightly when heated.

Does not effervesce in acids, even when reduced to powder. The specimen analyzed by Hisinger effervesced in acids, because it contained about the fourth part of its weight of carbonate of lime, which is absent in my specimen.

Easily frangible; specific gravity 2·2055; hardness 3·5.

Before the blowpipe it behaves nearly as table spar does. On the edges it fuses with difficulty into a semitransparent colourless glass. With borax it fuses easily, and forms an amethyst coloured glass.

Its constituents, determined by analyzing the specimen in my cabinet, are as follows:

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* Kong. Vetens. Acad. Handl. 1823, p. 177.

		Atoms.
Silica, . .	55·200 .	3
Lime, . .	34·284 .	1·06
Alumina, .	4·160 .	0·2
Protoxide of iron,	2·896 .	0·07
Moisture, .	3·400 .	0·3
	99·940	

If we omit the alumina, oxide of iron, and moisture, which amount only to a fraction of an atom, the mineral is obviously a compound of

3 atoms silica,
1 atom lime,

or its symbol is $CalS^3$.

Sp. 13. *Dysclasite.*

This mineral is found in the Faroe islands. Specimens of it were brought to Edinburgh by Count Vargus Bedemar of Copenhagen, who gave a few fragments of it to Sir D. Brewster, Mr. Rose, and probably other individuals. It was first described and analyzed, and its peculiar nature determined by Mr. Arthur Connel.

Colour white, with an opalescent tint.

Texture imperfectly fibrous, and it is obviously formed of a congeries of minute crystals; accordingly, when a thin slice of it was polished, it was found by Sir D. Brewster to be capable of polarizing light in all directions.

Translucent, and when in thin slices, transparent; refracts doubly; reflects a yellow, and of course transmits blue light.

Specific gravity 2·362.

Hardness about 4¼, but it is exceedingly tough; so much so that it is very difficult to break it, even by repeated blows of a hammer. Hence the name *dysclasite* bestowed upon it by Mr. Connel.

When heated in a glass tube it gives out pure water. Before the blowpipe per se it becomes opaque and white, and fuses only on the edges. With carbonate of soda melts with effervescence into a semitransparent glass. With biphosphate of soda it fuses into a colourless glass, leaving a silica skeleton. The bead opalizes on cooling, especially if the heat be continued a considerable time. With borax it fuses into a transparent colourless glass. When heated with soda on platinum foil it gives slight indications of the presence of manganese. Gelatinizes in muriatic acid.

Its constituents, as determined by the analysis of Mr. Connel, are

		Atoms.	
Silica, . .	57·69	. 28·84	
Lime, . .	26·83	. 7·66	
Water, . .	14·71	. 13·07	
Soda, . .	0·44	. 0·11	0·25
Potash, . .	0·23	. 0·04	
Peroxide of iron,	0·32	. 0·06	
Protoxide of manganese,	0·22	. 0·04	
	100·44		

Atoms of silica, . .	28·84	. 3·64
bases, . .	7·91	. 1
water, . .	13·07	. 1·65

Equivalent to $5CalS^4+CalS^2+9Aq$.

Leaving out the other bases, and supposing the silica combined with them in the same ratio as with the lime.

Sp. 14. *Sesquihydrous Arseniate of Lime.*

A single specimen of a mineral belonging to this species exists in the cabinet of Mr. Ferguson of Raith, and has been imperfectly described by Mr. Haidinger, and analyzed by Dr. Turner.* The locality of the specimen is unfortunately unknown.

The colour is white, and the streak white.

The specimen is crystallized in the form of an octahedron, with an oblique base.

Lustre glassy; translucent when in small crystals; sectile; hardness 2 to 2·5; specific gravity 2·848.

Its constituents, according to the analysis of Dr. Turner, are,

		Atoms.
Arseniate of lime, .	85·681	. 1
Water, . . .	14·319	. 1·597
	100·000	

or very nearly

1 atom arseniate of lime,
1½ atom water.

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* Poggendorf's Annalen, v. 189.

The small excess of water is undoubtedly mechanically lodged between the plates of the crystal.

Sp. 15. *Bisesquihydrous Arseniate of Lime.*

Pharmacolite, picropharmacolite.

This mineral was first observed by Selb in the mine of Sophia, near Wittichen, in Suabia. Selb ascertained its constituents to be arsenic acid, lime, and a little cobalt, to which it owed its red colour;* and these results were afterwards confirmed by an analysis by Klaproth.†

The colour of this mineral, when pure, is snow-white, but it is frequently tinged red by an admixture of arseniate of cobalt. Sometimes the colour is yellowish, owing probably to an admixture of iron ochre.

The structure is radiated, owing to the mineral being composed of a congeries of capillary crystals, so arranged as to form sphericles. Haidinger has described some crystals which he observed in the collection of Mr. Ferguson of Raith; he considers the primary form as an octahedron composed of eight triangular faces, alternately larger, but the crystals observed were right oblique prisms, having two of their terminal edges and two of the lateral edges replaced by tangent planes.‡

Lustre vitreous; but in the thin columnar particles of composition also pearly.

Translucent; sometimes opaque; sectile; hardness 2·5.

Selb states the specific gravity to be 2·536. Klaproth found it 2·640, and Haidinger states the specific gravity of the crystals to be 2·730.

The pure crystals in Mr. Ferguson's collection were analyzed by Dr. Turner, and found composed of

		Atoms.
Arseniate of lime, .	79·01 .	1
Water, . . .	20·99 .	2·53
	100·00	

This is obviously

1 atom arseniate of lime,

2½ atoms water.

The *picropharmacolite* of Stromeyer, from Riegelsdorf, in

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* Scherer's Jour. xxiii. 537.

† Beitrage, iii. 277.

‡ Poggendorf's Annalen, v. 181.

Hesse, is merely a variety of this species. He gives no farther description of it than stating that it occurs in balls having an earthy aspect. The constituents, as determined by Stromeyer, are,

		Atoms.
Arsenic acid,	46·971	6·47
Lime,	24·646	7·04
Magnesia,	3·218	1·29
Oxide of cobalt,	0·998	0·21
Water,	23·977	21·31
	99·810*	

There is obviously an excess of

0·78 atom lime,
1·29 atom magnesia,
0·21 atom arseniate of cobalt,

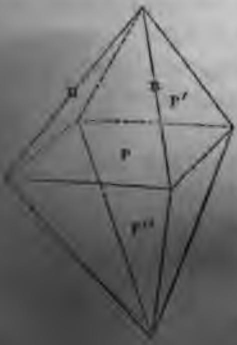
and the water, instead of 2½ atoms, amounts to 3½, very nearly; but a portion of it was probably mechanically lodged in the mineral.

Pharmacolite occurs in veins at Andreasberg, in the Hartz, and at Reichelsdorf, in Hesse, along with native arsenic, cobalt pyrites, &c.

Sp. 16. *Tungstate of Lime.*

Tungsten, scheelate of lime, scheelin calcaine.

This mineral, though rather scarce, had attracted the attention of mineralogists, and Cronstedt in his mineralogy published in 1758, describes it thus: *Ferrum calciforme, terra quadam incognita intime mixtum.* Scheele examined it in 1781, and pointed out its true nature.†



The colour is usually white, often inclining to yellow, grey, or brown. Some specimens are orange yellow

The mineral occurs usually in small detached crystals coating some other mineral, as quartz. The primary form of the crystal is an octahedron, with a square base.

P on P′ 100° 40′
P on P″ 128° 40′

The edges B are frequently replaced

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* [illegible]ungen, p. 135.

† [illegible] ad. Nya Handl. 1781, p. 89.

by tangent planes. When these new faces increase so much as to obliterate the primary faces, an octahedron is formed less acute than the primary. This last is the most usual form under which the mineral occurs.

The structure is imperfectly foliated; the cross fracture conchoidal; lustre glassy, inclining to adamantine; varies from translucent to semitransparent; hardness 6·5.

The specific gravity, as determined by Haidinger, is 6·076. Bucholz and Brandes found it to vary in different specimens from 5·959 to 6·076.[*]

Before the blowpipe it crackles, and becomes opaque, but does not melt. With borax it easily fuses into a white or transparent glass, according to the proportions employed.

We have three analyses of this mineral, one by Berzelius, and two by Bucholz and Brandes. The result of these is as follows:

	Berzelius.[†]	Bucholz and Brandes.[‡]	
Tungstic acid,	80·417	78·00	76·50
Lime,	19·400	19·06	16·50
Oxide of iron,	—	—	1·47
Silica,	—	2·80	2·94
Alumina,	—	—	1·09
	99·817	99·86	98·50

The mean of these analyses gives us very nearly

1 atom tungstic acid,	15·5
1 atom lime,	3·5
	19

which is doubtless the true constitution of the mineral.

Tungstate of lime is most commonly met with along with tin ore, both in veins and beds. In this way it occurs in Schlackenwald and Zinnwald, in Bohemia; Zinnwald and Ehrenfriedersdorf, in Saxony, and Pengelly Croft mine, in Cornwall. In Sweden and some other localities it is found along with octahedral iron ore. At Neudorf, in Anhalt-Bernburg, it occurs in veins traversing grey wacke. Splendid specimens have been found at Carroch, in Cumberland.

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[*] Schweigger's Jour. xx. 285.

[†] Afhandlingar, iv. 305.

[‡] Schweigger, xx. 285.

B. DOUBLE SALTS.

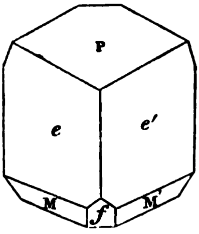
Sp. 17. *Glauberite.*

Brogniartine.

This mineral was discovered in 1807, by M. Alex. Brogniart, in specimens of common salt, brought by M. Dumeril from Ocagna, in New Castile.* It has been since observed at Aussee, in Upper Austria. It occurs also, but impure, in the common salt of Vic, in France.

Colour yellowish, or greyish white; streak white.

Massive, and also crystallized in very flat rhomboidal prisms, consisting of the planes P, *e*, *e′* of the annexed figure. But it readily yields to mechanical division, parallel to the planes P, M, M′ giving for its primary form a doubly oblique rhomboidal prism.



M on M′ 83° 20′
P on M or M′ 104° 15′
P on *e* or *e′* 137° 9′
P on *f* 112° 20′
M or M′ on *f* 131° 35′
e on *e′* 116° 20′

according to the measurement of Mr. W. Phillips.†

The faces *e*, *e′* are the result of tangent planes replacing the terminal edges of the primary prism. *f* is produced by the replacement of a lateral edge by a tangent plane.

Lustre vitreous; from semitransparent to translucent; brittle; hardness 2·5 to 3; specific gravity, as determined by Haidinger, 2·807. Broigniart states it at 2·73.

Taste saline, astringent, and weak.

When heated it decrepitates, and then melts into a white enamel; when put into water it becomes in a short time white and opaque; when taken out and dried, the white portion falls to powder, and when rubbed off discovers the central nucleus as transparent as ever.

According to the analysis of M. Brogniart, glauberite is a compound of

Sulphate of lime, . .	49
Sulphate of soda, . .	51
	100

Both being anhydrous.

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[*] Jour. des Mines, xxiii. 5.

[†] Mineralogy, p. 198.

This corresponds very nearly with

1 atom sulphate of lime,	. .	8·5
1 atom sulphate of soda,	. .	9
		17·5

Sp. 18. *Gay-Lussite.*

This mineral was discovered in the Natron lake, in Columbia, by M. Boussingault, who published an analysis and description of it.* The crystalline form was investigated by M. Cordier,† and afterwards from a more perfect specimen by Mr. W. Phillips.‡

It occurs in detached crystals in clay. The less perfect of them might readily be mistaken for selenite; while the more perfect and smooth have rather the aspect of calcareous spar.

These last are yellowish white and translucent, and refract doubly in a high degree, extremely brittle, easily reduced to a grey powder, and without phosphorescence, either from friction or heat.

Cross fracture conchoidal, and the surfaces produced, have a vitreous lustre.

The primary form of the crystal is, according to Mr. Phillips, a doubly oblique prism, the faces of which are inclined at an angle of 68° 50′. The inclination of the base to either of the contiguous sides 96° 30′. In general, the obtuse lateral edges of the prism are replaced by tangent planes.

Hardness 2·5; specific gravity from 1·928 to 1·990.

When heated in a matrass, the crystals decrepitate and become opaque. Before the blowpipe it melts rapidly into an opaque globule, which once formed is infusible, and has an alkaline taste. In nitric acid dissolves with brisk effervescence, and by spontaneous evaporation yields crystals of nitrate of soda, floating in a solution of nitrate of lime.

Its constituents, as determined by Boussingault, are,

		Atoms.	
Carbonate of soda,	33·96	5·03	1
Carbonate of lime,	31·39	5·02	1
Water,	32·20	28·62	5·72
Alumina,	1·00		
Carbonic acid,	1·45		
	100·00		

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* Ann. de Chim. et de Phys. xxxi. 270. † Ibid, p. 276.

‡ Phil. Mag. (new series), i. 263.

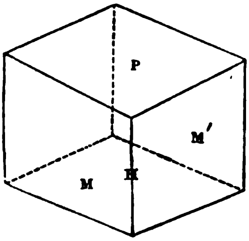
Obviously 1 atom carbonate of soda,
1 atom carbonate of lime,
6 atoms water.

Sp. 19. *Calcareo-Carbonate of Barytes.*

Baryto-calcite of Brooke and Children.

This mineral occurs in considerable quantity at Alston Moor, in Cumberland, both crystallized and massive. It was first described by Mr. Brooke, and analyzed by Mr. Children.* It has been noticed also by Mr. Haidinger.†

Its colour is white, with a shade of grey, yellow, or green; cross fracture uneven, and imperfect conchoidal.



The primary form of the crystal is an oblique rhombic prism.

P on M or M′ 102° 54′
M on M′ 106° 54′

The edge H and its opposite, are almost always replaced by tangent planes. Several other replacements occur on the other angles and edges, and the crystal is often lengthened in the direction of the modified planes.

Lustre vitreous, inclining to resinous; varies from translucent to transparent; hardness 4; specific gravity as determined by Mr. Children 3·66; by Mr. Richardson 3·6363.

Before the blowpipe it does not fuse per se; but melts easily with borax, or biphosphate of soda, into a transparent glass. It gives indications of the presence of a little iron and manganese.

According to the analysis of Mr. Children, its constituents are

Carbonate of barytes, .	13·178 to 14·5
Carbonate of lime, . .	6·72 to 7·39

Mr. Richardson subjected it to a careful analysis in my laboratory, and obtained,

		Atoms.
Carbonate of barytes, .	62·20 .	5·077
Carbonate of lime, . .	31·65 .	5·064
Sulphate of barytes, . .	0·30	
Peroxide of iron, . .	0·85	
Water, or volatile matter, .	3·15	
	98·15	

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* Annals of Philosophy (second series), viii. 114.

† Mohs' Mineralogy, iii. 76.

Obviously a compound of

1 atom carbonate of barytes, .	13·25
1 atom carbonate of lime, . .	6·25
	19·5

Sp. 20. *Bicalcareo-Carbonate of Barytes.*

I got the specimen of this mineral in my possession, and from which the description and analysis were made out, from Mr. Cowper, of the firm of S. Cowper and Sons, of Alston and Keswick, Cumberland. He exposed a collection of minerals from the north of England for sale in Glasgow, in the month of November, 1834. Upon looking at his minerals, I was attracted by the specimen as exhibiting something with which I was unacquainted, and purchased it for examination.

Colour snow-white.

Composed of dodecahedrons, consisting of two six-sided pyramids applied base to base. The faces were too rough to admit of being measured by the reflecting goniometer; but by the common goniometer the inclination of the face of one pyramid to the corresponding face of the other was as nearly as I could estimate 132°. The angles of the plane between the two pyramids could not be measured accurately, because few of the crystals were sufficiently disentangled to admit of the application of the goniometer. One that I measured was 110°, and another about 120°. I could observe no cleavage except in one instance, when the cross fracture exhibited what might be the face of a primary rhomboid.

These crystals were in groups, and proceeded from a white crystallized substance, which had the aspect of sulphate of barytes.

Lustre vitreous; fracture in general granular and uneven. In one case only I observed what had the appearance of a foliated fracture.

Translucent.

Hardness 2·25; specific gravity 3·718.

When dissolved in nitric acid it left 0·75 per cent. of sulphate of barytes. This I considered as accidental impurity derived from the base on which the crystals are deposited. The moisture also, which amounted to rather more than 2 per cent., was doubtless merely hygrometrical. Abstracting these two substances, which I consider as accidental impurities, I found the constituents to be,

		Atoms.
Carbonate of barytes,	49·31	or 4·02
Carbonate of lime,	50·69	or 8·01
	100·00	

This is obviously

1 atom carbonate of barytes,	12·25
2 atoms carbonate of lime,	12·5
	24·75

It therefore contains exactly twice the quantity of carbonate of lime that exists in the baryto-calcite of Mr. Brooke.

Sp. 21. *Baryto-Fluate of Lime.*

This mineral occurs in Derbyshire, constituting a bed an inch thick in a slaty limestone. In appearance it is very similar to grey compact limestone. Its specific gravity is 3·75. It was analyzed by Smithson, who found it composed of

Sulphate of barytes,	51·5
Fluoride of calcium,	48·5
	100·0

This corresponds with

1 atom sulphate of barytes,
3 atoms fluoride of calcium.*

Sp. 22. *Xanthite.*

This mineral occurs in small grains, and crystals in a limestone bed at Amity, Orange County, New York. From a specimen of it, which I received from Mr. Nutall about the year 1826, I was enabled to analyze it, and I gave it the name of *xanthite*, from the yellow colour by which it is distinguished.† Since that time, I have been favoured with a much more perfect specimen by the kindness of Dr. Torrey of New York.

Xanthite has a greyish yellow colour, and consists of a congeries of very small rounded grains, easily separable from each other, and not larger than small grains of sand. More lately Lieutenant Mather met with it in the same locality in foliated masses, which are very friable, and readily fall into grains, some of which are prisms about $\frac{1}{20}$th of an inch in length.*

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* Schweigger's Jahrbuch, i. 362. I have not seen this species noticed any where else; nor do I know where Smithson's analysis is consigned.

† See Annals of the Lyceum of Natural History of New York, for April, 1828.

It readily yields by cleavage a doubly oblique prism, whose faces are inclined to each other, according to Mr. Mather's measurement, as follows:

P on M 97° 30′
P on T 94°
M on T 107° 30′

The grains are translucent; some of them, indeed, are transparent; and Mr. Mather observed that the transparent portions refract doubly.

Hardness does not exceed 2; specific gravity 3·201; but that of the more perfect specimens which I afterwards got from Dr. Torrey, was 3·221.

According to Mather, it fuses per se before the blowpipe into a greenish translucent bead, which is slightly attracted by the magnet. I did not succeed in fusing it per se or when mixed with carbonate of soda. With borax it melts into a glass which is yellow while hot, but becomes colourless on cooling.

The result of two different analyses of this mineral was as follows:

Silica, . . .	37·708	35·092
Lime, . . .	36·308	33·080
Alumina, . .	12·280	17·428
Peroxide of iron, .	12·000	6·368
Protoxide of manganese,	3·680	2·801
Magnesia, . .	——	2·001
Water, . . .	0·600	1·680
	97·576	98·430

The second of these analyses was performed upon a purer specimen than the first. As the peroxide of iron and protoxide of manganese are much more abundant in the first specimen than the second, it seems reasonable to consider them as only accidentally present. For the same reason the magnesia cannot be essential. The atomic values of the three remaining constituents, are as follows:

	By 1st analysis.	By 2d analysis.
Silica, . .	16·35	17·54
Lime, . .	10·37	9·45
Alumina, . .	5·46	7·74

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* Poggendorf's Annalen, xxiii. 367.

If we take the two bases together and compare them with the silica, we have

	1st analysis.	2d analysis.
Silica, . .	16·35	17·54
Bases, . .	16·64	17·54

We see from this that the mineral is composed of simple silicates. The 2d analysis (which was on the purest specimen) gives us

6 atoms silicate of lime,
5 atoms silicate of alumina.

Hence the symbol of the constitution of xanthite is

$$6CalS+5AlS$$

From the first analysis I had concluded the composition to be $2CalS+AlS$.

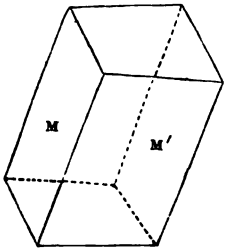
Sp. 23. *Borosilicate of Lime.*

Datholite, esmarkite, humboldtite.

This mineral was discovered by Esmark at Arendal, about the year 1805. It was afterwards found also in the Tyrol, and more lately at Andreasberg in the Hartz, and I have also specimens of it from Paterson in New Jersey. Its constitution was determined by Klaproth in 1806.*

The colour of datholite is white, sometimes inclining to green, yellow, or grey.

Texture imperfectly foliated; cross fracture imperfect conchoidal.



The primary form of the crystal is a right rhombic prism, in which

M on M′ 103° 25′

according to the measurement of Levy.

The obtuse edges of the prism H, are usually replaced by tangent planes. The terminal edges are also commonly replaced by planes more inclined to the faces M, than to the base of the prism. Finally, the solid angles of the prism are replaced by one, two, or more planes.†

The lustre is vitreous, but the faces of cleavage have a lustre inclining to pearly; translucent; streak white; hardness 4·25 to 5.

Specific gravity, as determined by Klaproth, of a specimen from Arendal, 2·980.* Haidinger found that of a specimen from Arendal, 2·989.† But the specific gravity of the Datholite from Andreasberg in the Hartz, is much higher, being found by Stromeyer to be 3·3463.

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* Beitrage, iv. 354.

† For a description of the modified crystal, the reader is referred to Mr. Levy, Annals of Philosophy (2d series), v. 130.

When this mineral is held in the flame of a candle it becomes opaque, and may be crumbled to powder between the fingers. Before the blowpipe it gradually fuses into a glassy globule. With borax and carbonate of soda it also easily fuses into a glass, which is colourless, if the mineral be pure.

We have two analyses of this mineral, one by Klaproth and another by Stromeyer. The following table exhibits the result of these analyses:

	Klaproth.	Stromeyer.
Silica, . . .	36·5	37·36
Boracic acid, . .	24·0	21·26
Lime, . . .	36·12	35·67
Water, . . .	4·0	5·71
	100·62‡	100·00§

Both of these analyses lie under the defect that the boracic acid was not actually obtained, but calculated from the loss of weight sustained during the analyses. If we take Stromeyer's as the most accurate, we have the constituents of datholite, as follows:

3 atoms tersilicate of lime,
2 atoms biborate of lime,
2½ atoms water.

The formula exhibiting its constitution therefore is,

$$3\mathrm{Cal}S^3+\mathrm{Cal}\dot{B}^2+2\tfrac{1}{2}\mathrm{Aq}.$$

Mr. Levy gives a description of some small brilliant transparent crystals from the Seisser Alps, which were considered as datholite, and which Dr. Wollaston found to contain the same constituents. Mr. Levy is of opinion, that these crystals||

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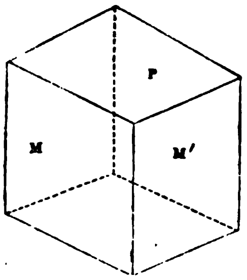
* Beitrage, iv. 356.

† Mohs' Mineralogy, ii. 223. There is reason to suspect these specific gravities; for Stromeyer informs us, that he took the specific gravity of a very pure specimen from Arendal, and found it 3·3541. See Poggendorf's Annalen, xii. 156.

‡ Beitrage, iv. 356. The quantity of lime found has been rectified.

§ Poggendorf's Annalen, xii. 157.

|| A figure of these crystals is given in the Annals of Philosophy (2d series), v. 131.



cannot be derived from a *right* rhombic prism but from an *oblique* rhombic prism, in which

M on M′ 115° 45′
P on M 91° 25′

This induces him to consider them as a new species, to which he has given the name of Humboldtite, an appellation already appropriated to the oxalate of iron by M. de Rivero. Levy's determination must remain doubtful till a sufficient quantity of the crystals be obtained, to admit of an accurate analysis.

Sp. 23. *Botryolite.*[*]

Biboro-silicate of lime.

This mineral which occurs in the Kjenlie mine at Arendal, in Norway, was first noticed by Haussmann during his travels in Norway. At his request, Assessor Gahn examined it by the blowpipe, and found it to contain silica, boracic acid, lime, and some alumina. It was afterwards analyzed by Klaproth.

The colour is pale rose red, pearl grey, yellowish white, or isabella yellow. These colours generally appear in concentric stripes.

Texture delicate, stellular fibrous, showing that it is composed of minute crystals.

It occurs only in botryoidal masses. Hence the name, *botryolite*, given it by Haussmann.

Lustre dull or glimmering, pearly; translucent; hardness 4, scratches glass with difficulty; specific gravity, as determined by Klaproth, 2·885.

Before the blowpipe it behaves exactly as datholite.

Its constituents as determined by Klaproth, are

		Atoms.	
Silica, . .	36	18	7·83
Boracic acid, .	13·5	4·37	1·9
Lime, . .	40·32	11·5	5
Peroxide of iron,	1	0·2	0·08
Water, . .	6·5	5·77	2·5
	97·32[†]		

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[*] From βοτρυς, a bunch of grapes.

[†] Beitrage, v. 123.

This approaches very nearly to

4 atoms bisilicate of lime,
1 atom biborate of lime,
$2\frac{1}{2}$ atoms water.

Hence the formula is $4CalS^2+Cal\dot{B}^2+2\frac{1}{2}Aq$. It differs in its constitution essentially from datholite, with which mineralogists have hitherto associated it.

Sp. 24. *Colophonite.*[*]

Topazolite, yellow garnet, allochroite, succinite.

This mineral occurs in the same kind of rocks as those which contain common garnet, but is rare.

The colour is various shades of yellow, often with a shade of brown or grey. It is said also to occur with a green colour, but I have never seen a specimen.

When crystallized it has the shape of the rhomboidal dodecahedron with its various modifications peculiar to the garnet.

Fracture imperfect conchoidal.

Lustre resinous; from shining to splendent.

Translucent, at least on the edges.

Hardness 6·75; specific gravity from 3·871 to 3·965.

Its constituents determined by the analysis of Trollé Wächtmeister,[†] are as follows:

Silica, . . .	35·10	35·64
Protoxide of iron, .	29·10	30
Protoxide of manganese,	7·08	8·02
Magnesia, . . .	——	2·35
Lime, . . .	26·91	29·21
	99·17[‡]	100·22[§]

The mean of these two analyses gives us the atomic proportions as follows:

	Atoms.
Silica, . . .	17·68
Protoxide of iron, .	8·79
Protoxide of manganese,	1·22
Magnesia, . .	0·94
Lime, . . .	8·01

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[*] Named from its resemblance to resin.

[†] Kong. Vet. Acad. Handl. 1823, p. 133.

[‡] From Längbanshittan. Sp. gravity 3·965.

[§] From the neighbourhood of Altenau, in dodecahedral crystals. Sp. gravity 3·871.

Leaving out the oxide of manganese, the atoms of the bases are 17·74, and those of silica 17·68. Hence the mineral is composed of simple silicates. And joining the magnesia to the lime, the constitution will be

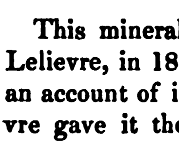
1 atom silicate of lime,
1 atom silicate of iron.

Sp. 25. *Ilvaite.*[*]

Yenite, lievrite, fer-calcareo-siliceux.

This mineral was brought from the Isle of Elba by M. Lelievre, in 1802. He studied its characters, and published an account of it in the Journal des Mines for 1807.[†] Lelievre gave it the name of Yenite, to commemorate the battle of Jena, which had been recently fought. Gehlen, in a letter to Delametherie, remonstrated against this name as an insult to the Prussian nation[‡]. Werner gave it the name of *Lievrite*, in honour of the discoverer. The name *Ilvaite* seems to have been substituted by the French mineralogists instead of Yenite, in consequence of the remonstrance of Gehlen.

The colour of Ilvaite is iron black, with a shade of brown or green. The fracture is imperfectly conchoidal.



It occurs usually in long prismatic crystals; and the primary form obtained from natural cleavage, is a right rhombic prism.

M on M′ according to Lelievre, 112° 37′ 9″
Brooke, 112°
Phillips, 111° 30′

The most usual form is a long oblique four-sided prism terminated by a low four-sided pyramid. The inclination of a side of the pyramid to the corresponding face of the prism, is 128° 50′. The pyramid is usually without its apex, in consequence of a portion of the base of the primary prism still remaining. The inclination of a face of the pyramid to this base, is 141° 10′. Sometimes the lateral edges of the prism are replaced by one or two faces. The lateral faces of the prism are usually longitudinally striated.

Lustre imperfectly metallic; opaque; hardness 4·75 to 5; specific gravity, as determined by Haidinger, 3·994.[§] Stromeyer found it 3·9796.* Lelievre found that of different specimens 3·825, 3·974, 3·985, 4·061.†

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[*] Named from the island of Elba, where it was first found.

[†] Vol. xxi. p. 65.

[‡] Gehlen's Jour. x. 38.

[§] Mohs' Mineralogy, ii. 415.

Before the blowpipe on charcoal it fuses into a black globule, which becomes vitreous in the external flame. In the interior flame the surface becomes dull, and it is attracted by the magnet, provided the globule has not been heated to redness. With borax it fuses into a dark, almost black glass; with carbonate of soda, into a black glass. With biphosphate of soda it leaves a skeleton of silica, and gives a glass strongly coloured by iron.

We have three analyses of this mineral, one by Collet Descotils, another by Vauquelin, and a third by Stromeyer. The specimens analyzed by each were from Elba. The following table exhibits the results obtained.

	Descotils.‡	Vauquelin‡. 1	2	Stromeyer.§
Silica,	28	29	30	29·278
Lime,	12	12	12·5	13·779
Protoxide of iron,	55	57	57·5	52·542
Protoxide of manganese,	3			1·587
Alumina,	0·6	—	—	0·614
Water,	—	—	—	1·268
	9·86	98	100·0	99·068

Stromeyer's analysis, which is probably the most correct, corresponds with the following atomic quantities.

3·72 atoms silica,
1 atom lime,
2·97 atoms protoxide of iron,
0·089 atom protoxide of manganese,
0·056 atom alumina.

If the alumina and protoxide of manganese be considered as combined in the mineral with two atoms of protoxide of iron, and these compounds to be accidental, then ilvaite will be a compound of

1 atom silicate of lime,
3 atoms silicate of iron,

and the formula denoting its composition will be $\mathrm{CalS}+3\underline{\mathrm{f}}\mathrm{S}$.

This mineral has been found rather abundantly in limestone among the primary rocks of Elba. It has been observed also at Kupferberg in Silesia, at Fassum in Norway, in Siberia, in North America, and I have a specimen of it from Greenland.

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* Untersuchungen, p. 373.

† Jour. des Mines, xxi. 66.

‡ Jour. des Mines, xxi. 70.

§ Untersuchungen, p. 374.

Sp. 26. *Hedenbergite.*

This mineral was first observed in Marmor's mine, Tunaberg, in Södermanland, Sweden; where it is associated with calcareous spar. It was described and analyzed by M. A. Ludvig Hedenberg in the year 1807.*

Its colour is greenish black; sometimes inclining to dark green, sometimes to brown.

Structure foliated. Mr. W. Phillips informs us, that it yields by mechanical division a rhombic prism, the faces of which are inclined to each other at angles of 124° 30′ and 55° 30′. But Hedenberg affirms that its shape is precisely the same as that of calcareous spar.

Lustre shining; surface of the cleavage faces streaked; streak olive green.

Hardness 3·5; specific gravity 3·154.

Before the blowpipe it fuses with a very slight effervescence into a black, shining glass. With borax it fuses easily into a glass coloured by iron. With biphosphate of soda it fuses into a bead at first yellow; but becoming at last dark red. These colours are destroyed by the deoxidizing flame. With carbonate of soda it fuses into a greyish green bead, which blackens when the heat is increased.

Its constituents as determined by the analysis of H. Rose, are

		Atoms.	
Silica,	49·01	24·5	4·23
Lime,	20·87	5·96	1·03
Magnesia with manganese,	2·98	1·2	0·20
Protoxide of iron,	26·08	5·79	1
	98·94†		

It is obvious that it consists of bisilicates of lime and iron, and of silicate of magnesia. And if we neglect the small quantity of silicate of magnesia, amounting only to one-fifth of an atom, the constitution of it is

1 atom bisilicate of lime,
1 atom bisilicate of iron.

The formula is $CalS^2 + fS^2$.

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[*] Afhandlingar, ii. 164.

[†] Kong. Vet. Acad. Handl. 1820, p. 328.

Sp. 27. *Ligurite.*

This mineral has hitherto been described and analyzed by Viviani alone. Never having seen it, I can only introduce the very imperfect description given of it by him. It was found on the banks of the Stura in the Appenines, in a talcose rock.

The colour is apple green; streak greyish white; fracture uneven.

Primary form an oblique rhombic prism, with angles of 140° and 40°.

Lustre between vitreous and resinous; transparent to translucent; hardness above 5; used as a gem; specific gravity 3·49.

Its constituents as determined by Viviani, are

			Atoms.
Silica,	57·45	28·725	7
Lime,	25·30	7·22	1·75
Alumina,	7·36	3·22	0·78
Magnesia,	2·56	1·02	0·23
Oxide of iron,	3·00	0·66	0·16
Oxide of manganese,	0·50	0·11	0·02
	96·17*		

If we unite the magnesia and lime, and the alumina with the oxides of iron and manganese, the mineral will consist of

2 atoms tersilicate of lime,
1 atom silicate of alumina.

The formula will be $2CalS^3+AlS$.

The tersilicate of magnesia and the silicates of iron and manganese may be foreign bodies.

Sp. 28. *Sphene.*†

Brunon, semelin, spinellane,‡ spinthere, rayonnante en gouttiere, braunmenakerz, and gelbmenakerz.

This mineral seems to have been first noticed by Saussure, who described it under the name of *rayonnante en gouttiere*, in his *Essai de la Lithologie du St. Gothard.*

The colours are brown, yellow, green, and grey. These colours are not lively, if we except some yellow, and some pistacio green varieties.

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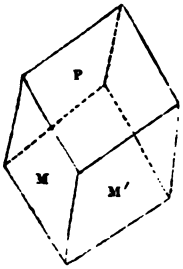
* Mohs' Mineralogy, iii. 121.

† From σφην, a wedge.

‡ *Spinellane* is applied also to quite a different mineral. See Mohs' Mineralogy, iii. 156.

The texture is foliated, with a very apparent cleavage in one direction, less distinct in another; cross fracture conchoidal.



It is always crystallized, and the primary form of the crystal, as determined by M. G. Rose, is an oblique rhombic prism.

M on M′ 76° 2′
P on M or M′ 93° 1′

It occurs most commonly in very oblique prisms, the greater angles of which are about 136°.

Lustre vitreous, or even adamantine; in some varieties inclining to resinous.

Varies from transparent to translucent on the edges; hardness 5 to 5·5; the specific gravity, as determined by Haidinger, 3·468. Cordier found that of a specimen from St. Gothard 3·2378; and a specimen from Passau, analyzed by Klaproth, was 3·510.

Before the blowpipe it fuses with difficulty on the edges into a dark coloured glass. With carbonate of soda it fuses into an opaque glass, which becomes greyish white on cooling. With borax it fuses pretty readily into a clear yellow transparent glass. With biphosphate of soda it melts with difficulty, and the unfused portion is milk-white.*

We have two analyses of this mineral, one by Klaproth, and another by Cordier; but neither is likely to be quite accurate, as they were made before the characters of titanic acid were fully developed.

Silica, . .	35 .	28
Titanic acid, .	33 .	33·3
Lime, . .	33 .	32·2
	100†	93·5‡

Klaproth analyzed another variety of sphene from Salzburg, and found its constituents as follow:

Silica, . . .	36
Titanic acid, . .	46
Lime, . . .	16
Water, . . .	1
	99§

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* Berzelius on the Blowpipe, p. 256.

† Klaproth, Beitrage, i. 251. ‡ Cordier, Jour. des Mines, xiii. 70.

§ Beitrage, v. 243.

Notwithstanding the great difference in the constitution of the two varieties resulting from the analyses, their characters agree very nearly with each other.

Our uncertainty respecting the atomic weight of titanic acid makes it difficult to estimate the constitution of sphene from these analyses. They agree best with the supposition that it consists of

1 atom tersilicate of lime,
1 atom titaniate of lime.

The formula on that supposition will be $CalS^3+Cal\dot{T}t$.

Sphene is found interspersed among primary rocks, particularly granite, gneiss, and chlorite. It occurs in some of the oldest veins, and it is said also in trap rocks. It is almost a constant ingredient in syenite.

C. TRIPLE AND QUADRUPLE SALTS.

Sp. 29. *Raphilite.**

I have given this name to a mineral from the township of Perth, in Upper Canada. For the specimen subjected to analysis, and from which the description of the mineral was drawn up, I am indebted to Dr. Holme of Montreal, to whose zeal the mineralogy of Canada lies under very considerable obligations.

Colour white, with a shade of bluish green.

The stone is composed of needle-form crystals, diverging slightly as if from a centre. These needles, when viewed under the microscope, appear to be four-sided oblique prisms.

Lustre between glassy and silky; hardness 3·75; the needles or fibres easily separable from each other; they are slightly flexible, but easily broken; specific gravity 2·85.

Before the blowpipe becomes opaque and white, and the extremity of the fibre is rounded off, but does not fuse into a globule. With carbonate of soda it melts slowly, and with effervescence into a translucent white glass. Fuses with borax into a transparent colourless glass, leaving silica. In biphosphate of soda it does not dissolve, or only very imperfectly, leaving a white substance (silica) considerably more bulky than the original assay.

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* From ραφις, a needle, from the structure of the stone.

This mineral yielded by analysis the following constituents:

		Atoms.	
Silica,	56·478	28·24	7
Lime,	14·750	4·2	1·03
Alumina,	6·160	2·73	0·67
Protoxide of iron,	5·389	1·3	0·32
Protoxide of manganese,	0·447		
Magnesia,	5·451	2·18	0·54
Potash,	10·533	1·75	0·43
Moisture,	0·500		
	99·708		

These numbers correspond pretty well with this formula,

$$CalS^3+(\tfrac{2}{3}Al+\tfrac{1}{3}f)S^2+(\tfrac{1}{2}k+\tfrac{1}{2}mn)S^2.$$

which therefore represents the constitution of raphilite.

Sp. 30. *Polyadelphite.*[*]

The mineral to which I have given this name, from the complex nature of its constitution, was sent me by Mr. Nutall, and its locality I believe to be Franklin, New Jersey.

Colour yellow of different shades, wine yellow, and greenish yellow. The colours are not bright.

The mineral is composed of translucent roundish grains, and of imperfectly foliated masses agglutinated together.

Lustre resinous; mass opaque; small grains translucent.

The hardness at first was only 3·25, but after remaining in my cabinet for several years, it became 4·75. Specific gravity 3·767; brittle.

Before the blowpipe blackens, and assumes the appearance of magnetic iron ore, but does not fuse. With carbonate of soda it fuses into a green glass, which becomes black and opaque in the oxidizing flame. With borax fuses into a dark brown opaque glass; with biphosphate of soda it fuses slowly into a transparent coloured glass, leaving a silica skeleton. Its constituents are,

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[*] From πολυς, and αδηλφος, a brother. So named because it consists of five different silicates united.

		Atoms.
Silica,	36·824	18·422
Lime,	24·724	7·06
Protoxide of iron,	22.948	5·09
Protoxide of mangan.,	4·428	0·98
Magnesia,	7·944	3·17
Alumina,	3·356	1·48
Moisture,	0·550	
	100·774	

These numbers give us the following formula for the constitution of this mineral:

$$7CalS+5\underline{f}S+3MgS+1\tfrac{1}{2}AlS+\underline{mn}S.$$

It is therefore a quintuple salt, or we may consider it as

$$5CalS+4(\tfrac{5}{6}f+\tfrac{1}{6}mn)S+2MgS+AlS.$$

Sp. 31. *Pektolite.*[*]

M. von Kobell has given this name to a mineral which is found on natrolite, on Monte Baldo, in South Tyrol.

Colour greyish.

Occurs in spheroidal masses, which have a columnar composition, and consist of delicate flat needles, diverging from a centre.

Surface generally dull; lustre pearly at the fracture.

Hardness 4·5; specific gravity 2·69. Its constituents, according to Kobell, are,

		Atoms.	
Silica,	51·30	25·65	11
Lime,	33·77	9·64	4·15
Soda,	8·26	2·06	1
Potash,	1·57	0·26	
Alumina and oxide of iron,	0·90	—	
Water,	8·89	7·9	3·4
	104·69		

This is obviously (including the potash with the soda),

4 atoms bisilicate of lime,
1 atom tersilicate of soda,
3½ atoms water.

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[*] Kastner's Archiv. xiii. 385.

GENUS VIII.—MAGNESIUM.

Magnesium, like the bases of the other alkaline earths, has too great an affinity for oxygen, ever to exist on the surface of the earth in the metallic state. It is always in the form of *magnesia*, and, like the other alkaline earths, magnesia is always combined either with water or with an acid. Though magnesia is not nearly so abundant a constituent of the globe of the earth as lime, and though it is not met with combined with so many different acids, yet, from the great number of proportions in which it is found united to silica, and the various ways in which the magnesian silicates enter into combination with other silicates, it happens that the number of species belonging to this genus rather exceeds those belonging to the preceding genus.

A. SIMPLE SALTS.

Sp. 1. *Hydrate of Magnesia.*

Brucite of the American mineralogists.

This beautiful mineral was discovered by Dr. Bruce, in the serpentine of Hoboken, in New Jersey. Much finer specimens of it have been found at Swinaness, in Unst, one of the Shetland islands, by Dr. Hibbert. In this place, as at Hoboken, it is in veins traversing serpentine.

Colour white, inclining to green.

Texture foliated, and the mineral is easily split into thin flexible laminæ.

Lustre pearly, splendent.

It has been observed crystallized in low six-sided prisms; but in general no regular shape can be discovered. At Hoboken, in New Jersey, it occurs on serpentine in needleform crystals diverging from a centre.

Translucent, at least on the edges; sectile; hardness 1; specific gravity, as determined by Haidinger, 2·350.

Before the blowpipe it gives out water, but does not fuse. By the oxygen and hydrogen blowpipe, however, small portions of it may be fused into an enamel.

We have several analyses both of the New Jersey and the Swinaness varieties. The following table exhibits the results.

	*	†	‡	§
Magnesia, . . .	64	68·345	66·67	67·98
Water, . . .	29	30·902	30·30	30·96
Protoxide of manganese,	—	0·637	1·57	1·57
Protoxide of iron, .	2·5	0·116	1·18	
Lime, ...	—	——	0·19	—
Silica, ...	2	——	—	—
	97·5	100·000	99·91	100·52

The oxides of manganese, and iron, and lime, are only accidental ingredients. It is obviously a compound of

1 atom magnesia, . .	2·5
1 atom water, . .	1·125
	3·625

Sp. 2. *Carbonate of Magnesia.*

Baudisserite, razoumuffskin, magnesite.

This mineral was first observed in Germany, in small quantities; and afterwards at Hoboken, in New Jersey, where it traverses serpentine in veins. It was found at Baudissero, at Piedmont, and in various parts of Germany. In the peninsula of Hindostan it would seem to abound; for about twelve years ago Mr. Babington brought home a cargo of it from India, and he informed me that in that country it constitutes a range of low hills. I have also specimens from one of the islands in the Indian Archipelago.

The colour is yellowish white; the fracture flat conchoidal, and sometimes earthy.

Hitherto observed only massive, and composed of very fine particles without the smallest tendency to crystallization.

Dull; opaque, or feebly translucent on the edges; hardness 4·5; exceedingly difficult to break. Owing to this circumstance, it sometimes strikes fire with steel; though, from its softness, one would not expect this to happen. There is a

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[*] Vauquelin; Ann. de Mus. d'Hist. Nat. xx. 167.

[†] Stromeyer; Untersuchungen, p. 407.

[‡] Stromeyer; Annals of Philosophy (second series), x. 232.

[§] By my analysis. The specimen was from Swinaness, as was also that which constituted the second analysis of Stromeyer. The two first analyses in the table were from specimens from New Jersey.

variety found at Baumgarten, which, according to Haussmann, is harder than the common carbonate of magnesia. The magnesian marble of Nutall is the same with this variety.

Breithaupt found the specific gravity 2·808. Klaproth found it 2·915.* According to Stromeyer, the specific gravity of the hard variety from Baumgarten is 2·95.†

When exposed to the blowpipe on charcoal, it shrinks a little, and then acts upon vegetable blues, like magnesia. With borax, or biphosphate of soda, it fuses into a glass. When heated in contact with nitrate of cobalt, it assumes a flesh red colour.

It dissolves very slowly in dilute sulphuric or nitric acid. The solution does not take place well unless the mineral be in powder, and heat be applied.

We have five different analyses of this mineral, the results of which may be seen in the following table:—

	‡	§	‖	¶	**
Carbonic acid, . .	49	50·7512	51	51·35	51·83
Magnesia, . .	48	47·6334	46	48·03	47·88
Protox. of manganese,	—	0·2117	—	0·62	trace
Insoluble matter, . .	—	—	1·5	—	trace
Lime, ...	—	—	—	—	0·28
Water, . . .	3	1·4037	0·5	—	—
	100	100	99	100	99·99

It is obvious that the mineral is a compound of

1 atom carbonic acid, .	2·75	or 52·381
1 atom magnesia, . .	2·5	or 47·619
	5·25	

There is a very slight deficiency of carbonic acid. Probably the external crust of this mineral is liable to lose a little of its acid. At least, I find that this happens with the artificial carbonate of magnesia.

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* Beitrage, v. 99. † Untersuchungen, p. 121.

‡ Klaproth, Beitrage, v. 100.

§ Stromeyer, Untersuchungen, p. 133. It was the hard variety from Baumgarten.

‖ Henry; Annals of Philosophy (second series), i. 252.

¶ By my analysis, the specimen was from Sulem, in India. In the manganese, there was a trace of lime.

** *Stromeyer;* Annals of Philosophy (second series), x. 233. The *specimen was from Sulem,* in India.

This species was discovered by Dr. Mitchell, about the year 1800, at Hrubschitz, in Mähren.

Sp. 3. *Hydro-Carbonate of Magnesia.*

This mineral occurs at Hoboken, in New Jersey, in serpentine, along with the various magnesian minerals, which have rendered that locality so famous.

It is a white powder exactly similar in its appearance to *magnesia alba.*

It was analyzed by Trollé-Wāchtmeister, who obtained the following constituents:—

		Atoms.	
Magnesia,	42·41	17	13
Carbonic acid,	36·82	13⅕	10·19
Water,	18·53	16½	12·6
Silica,	0·57		
Peroxide of iron,	0·27		
Foreign matter,	1·39		
	99·99*		

These numbers approach nearest to

{ 5 atoms bicarbonate of magnesia,
{ 8 atoms sesquihydrate of magnesia.

How far this represents the real constitution of the mineral is doubtful.

Sp. 4. *Sulphate of Magnesia.*

Epsom salt—hair salt—hollotrichum.

This salt occurs pretty frequently as an efflorescence on other minerals. Thus it occurs at Freiberg as an efflorescence on gneiss. We meet with it also in Scotland, and in different parts of Germany.

Colour white; fracture conchoidal.

It crystallizes in right rhombic prisms, very nearly rectangular; the greater angle being 90° 38′.

Lustre vitreous; transparent to translucent; hardness 2·25; specific gravity 1·751; soluble in water; taste bitter.

Before the blowpipe on charcoal it is converted into sulphuret of magnesium.

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* *Kong. Vet. Acad.* Handl., 1827, p. 17.

Its constituents are,

1 atom sulphuric acid, . .	5
1 atom magnesia, . . .	2·5
7 atoms water, . . .	7·875
	15·375

Sp. 5. *Reissite.*[*]

Soda sulphate of magnesia.

This name was given by Karsten to a salt first analyzed and made known by Reuss.[†] It occurs in the neighbourhood of Sedlitz.

It constitutes a meally efflorescence, in loose, earthy, dull particles, and likewise crystallized in needles, and in flat six-sided prisms; colour snow-white; taste saline and bitter; soluble in water.

Its constituents, according to the analysis of Reuss, are,

Sulphate of soda, . .	66·04
Sulphate of magnesia, .	31·35
Muriate of magnesia, .	2·19
Sulphate of lime, . .	0·42
	100·00

This corresponds with

16 atoms sulphate of soda,
9 atoms sulphate of magnesia.

But the analysis is an old one, and therefore probably not very accurate.

It is not unlikely that this salt may be found ultimately to be a compound of

2 atoms sulphate of soda,
1 atom sulphate of magnesia.

Sp. 6. *Bloedite.*

This name has been given by Dr. John to a saline substance which occurs at Ischel, in Upper Austria, and which seems to be a mixture of sulphate of magnesia, sulphate of soda, and common salt.

It is in irregular columns, has an uneven and splintery fracture, a vitreous lustre, and a brick-red colour. It is translucent, but becomes opaque and white by decomposition. It is soft.

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[*] I place this salt and the next here, though they are not simple salts, on account of their intimate connexion with sulphate of magnesia.

[†] *This word is pronounced in Germany, Reiss.* Hence, the appellation *reissite.*

Its constituents, as determined by John, are,

Sulphate of magnesia,	36·66
Sulphate of soda,	33·34
Common salt,	22·00
Sulphate of manganese,	0·33
Water,	0·34
	92·67

Together with a quantity of sulphated peroxide of iron with excess of base.

These numbers approach

3 atoms common salt,
4 atoms sulphate of soda,
5 atoms sulphate of magnesia.

But it is probable, that Bloedite is nothing more than a mixture.

Sp. 7. *Biborate of Magnesia.*

Boracite.

This mineral was first observed in a gypsum hill, near Luneburg, in the Dutchy of Brunswick. It was brought to Luneburg, where it was familiarly known by the name of *cubic quartz;* but little attention was paid to it till Westrumb examined it in 1788, and discovered in it *boracic acid*, magnesia, and lime.[*] Vauquelin afterwards showed, that the lime was only accidental, and that it was essentially a compound of boracic acid and magnesia.[†]

Colour white, inclining to grey, yellow, or green; streak white; fracture conchoidal, uneven.

It is always crystallized in small cubes, having their edges

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[*] Crell's Annalen, 1788, ii. 483.

His analysis gave,

Boracic acid,	65
Magnesia,	20·5
Lime,	7
Oxide of iron,	1·25
Alumina,	2·25
Silica,	1·00
Water,	2·00
	99

Westrumb *gave it the name of muriatico-calcareus*, or *sedative spar.*

[†] *Hauy's Mineralogie*, ii. 57.

and alternate solid angles replaced by tangent planes. It occurs also in rhomboidal dodecahedrons.

Lustre vitreous; semitransparent to translucent. According to Dr. Brewster, it has one axis of double refraction. Hardness 4·25; specific gravity, as determined by Haidinger, 2·974. Westrumb states it at only 2·566, but the crystals which he examined were impure.

When heated, the eight solid angles became electric; four of them positive and four of them negative. On cooling, the state of electricity in each pole is reversed.

Before the blowpipe on charcoal, it fuses and intumesces. It is difficult to obtain the globule transparent. On cooling, it is bristled over with needle crystals. With borax it fuses into a transparent glass tinged with iron. With biphosphate of soda it fuses into a transparent glass, capable of becoming opaque by flaming. With carbonate of soda it fuses. If only the quantity necessary to procure a transparent glass be used, the assay on cooling forms crystals with broad facets as perfect as those of phosphate of lead.[*]

If boracite, previously decomposed by soda, be dissolved in muriatic acid, and a paper dipt in the solution be dried, and then moistened with alcohol, and burnt while moist, the flame towards the end of the combustion is tinged green.

We have two accurate analyses of this mineral, one by Stromeyer, and another by Arfwedson. The result of these is as follows:-

	[†]	[‡]
Boracic acid, . .	67 .	69·7
Magnesia, . . .	33 .	30·3
	100	

It is a biborate of magnesia, or a compound of

2 atoms boracic acid, .	6 .	70·588
1 atom magnesia, . .	2·5 .	29·412
		100·000

Hitherto boracite has been found only in two places, Luneburg and Segenberg, in Holstein. In both places it is imbedded in gypsum.

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[*] Berzelius on the Blowpipe, p. 236.

[†] Stromeyer, Gilbert's Annalen, xlviii. 215.

[‡] Arfwedson; Kong. Vet. Acad. Handl., 1822, p. 92.

Sp. 8. *Hydroboracite.*

Hydrous calcareo-biborate of magnesia.

This mineral was found by M. Hess in a collection of ucasian minerals. It had been taken for gypsum.

Colour white, but with spots of red from silicated peroxide iron, and very like both fibrous and foliated gypsum; hard-ss the same as that of gypsum.

The thin plates are translucent.

The specific gravity is 1·9.

The whole mass is full of holes, which are filled with clay, ntaining different salts.

Its constituents, as determined by two different analyses of . Hess, are as follows:—*

	1st.	2d.	Mean.	Atoms.	
Lime, . . .	13·298	13·74	13·519	3·86	0·91
Magnesia, . . .	10·430	10·71	10·570	4·20	1
Boracic acid, . .	49·922	49·22	49·571	16·52	3·93
Water, . . .	26·330	26·33	26·330	23·4	5·57
	99·980	100·00			

The constituents are obviously,

1 atom lime,
1 atom magnesia,
4 atoms boracic acid,
5½ atoms water.

Hence the constituents are,

1 atom biborate of lime,
1 atom biborate of magnesia,
5½ atoms water.

The formula is $Ca\dot{B}^2+Mg\dot{B}^2+5\frac{1}{2}Aq$.

Sp. 9. *Chrysolite.*

Anhydrous silicate of magnesia, peridot, olivine, chusite.

The colour of this mineral is green of various shades; pis-chio, olive, asparagus, grass-green, sometimes passing into own, streak white.

It occurs both in crystals and amorphous. The primary rm of the crystal is a right rectangular prism; the longitudinal edges of which are often replaced by one, or sometimes by two planes. The terminal edges of the prism are also frequently replaced by faces, which nearly obliterate the base of the prism, though not completely in any crystal that I have seen. The crystallized specimens (which come from the Levant) are known in commerce by the name of *chrysolite;* while the granular specimens so common in basalt and greenstone are called *olivine,* from their olive-green colour.

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* *Poggendorf's Annalen*, xxxi. 49.

Cross fracture conchoidal; lustre vitreous.

Varies from transparent to translucent. The transparent varieties are occasionally used for ornamental purposes; but they are not much valued.

Hardness 6·5 to 7.

Haidinger found the specific gravity of a crystal of chrysolite 3·41.[*] Stromeyer[†] found the specific gravity of pure grains of olivine to vary from 3·3386 to 3·3445; while he found that of a crystal of chrysolite to be 3·3514. The specific gravity of the olivine in Pallas's meteoric iron was determined by the same chemist to be from 3·3404 to 3·3497.

Chrysolite does not fuse before the blowpipe, nor lose its transparency; but becomes brown on the edges. With borax and biphosphate of soda, it fuses into a glass coloured by iron, but giving no indication of iron by saltpetre. With soda, it is very slowly converted into a brown scoria.

The following table exhibits the constituents of this mineral as determined by chemical analysis:—

	‡	§	‖	‖	‖	¶	¶	¶
Silica, . . .	39	38	39·73	40·09	40·45	38·48	38·25	61.88
Magnesia, . . .	43·5	50·5	50·13	50·49	50·67	48·42	49·68	25·83
Protoxide of iron, .	19·0	9·5	9·19	8·17	8·07	11·19	11·75	9·12
Oxide of nickel, .	—	—	0·32	0·37	0·33	—	—	—
Oxide of manganese,	—	—	0·09	0·20	0·18	0·34	0·11	9·31
Oxide of chromium,	—	—	—	—	—	—	—	0·33
Alumina, . . .	—	—	0·22	0·19	0·19	0·18	—	—
Driven off by heat, .	—	—	—	—	—	—	—	0·45
	101·5	98	99·68	99·51	99·89	98·61	99·79	106·92

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[*] Mohs' Mineralogy, ii. 346.

[†] Poggendorf's Annalen, iv. 195.

[‡] Klaproth, Beitrage, i. 110.

[§] Vauquelin; Ann. de Chim. xxi. 97.

[‖] Stromeyer; Poggendorf's Annalen, iv. 194. The first specimen was a crystallized *chrysolite;* the two last *olivine.*

[¶] Stromeyer. Ibid. The specimens were of grains of olivine, contained in Pallas's meteoric iron. The last specimen, though resembling olivine *was obviously* a different substance. Its specific gravity was 3·2759.

Walmstedt, in the Memoirs of the Stockholm Academy for 1824, has published the result of a very careful analysis of six specimens of olivine. The following table exhibits the results which he obtained:—

	*	*	*	*	*	*	†
Silica, . . .	41·54	41·42	41·44	40·83	40·08	40·16	40·8
Magnesia, . .	50·04	49·61	49·19	47·74	44·24	44·87	41·6
Protoxide of iron,	8·66	9·14	9·72	11·53	15·16	15·38	16·4
Protox. of mangan.,	0·25	0·15	0·13	0·29	0·48	0·10	—
Lime, ...	—	—	0·21	trace	—	—	—
Alumina, . . .	0·06	0·15	0·16	trace	0·18	0·10	—
	100·55	100·47	100·85	100·39	100·24	100·61	98·8

When we consider these analyses, we cannot avoid observing, that the silica is nearly constant the greatest amount, being 41·54. The magnesia in the purest specimens approaches 50 per cent. The protoxide of iron is much more variable, the least quantity being 8, and the greatest 16·4 per cent. In crystallized chrysolite the constitution is

1 atom silica,
1 atom magnesia,
$\frac{1}{10}$th atom protoxide of iron.

The quantity of iron being small and variable is probably only accidental. If that were admitted, chrysolite would be a simple anhydrous silicate of iron.

From Mitcherlich's experiments it appears, that silicate of iron, when fused and slowly cooled, assumes a crystalline form, which agrees in its measurement with chrysolite. Probably, therefore, there are two species of minerals, which have nearly the same crystalline form; namely, *silicate of magnesia* and *silicate of iron.* Olivine is sometimes almost pure silicate of magnesia; but frequently, also, it is contaminated with silicate of iron. An account of this last mineral will be given in the 15th genus, when we treat of iron and its native compounds.

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* Kongl. Vet Acad. Handl., 1824, p. 259. The first specimen was from Iserwiese, in Silesia; the second from Bohemia; the third from the Vivarais; the fourth from Siberian meteoric iron; the fifth and sixth from Monte Somma.

† Berthier, *Memoires par i. 70.* The specimen was from Langeoc, in *the Department of the Haute Loire.*

Sp. 10. *Nemalite.*

Siliceous hydrate of magnesia.

This mineral occurs in veins in the serpentine rocks at Hoboken, in New Jersey. It was first described and its constituents determined by Mr. Nutall.*

Colour white, with a slight shade of yellow.

Composed of elastic fibres, easily separable, and bearing a striking resemblance to asbestus.

Hardness about 2; specific gravity, by my trials, 2·353. Mr. Nutall found it 2·44.

By exposure to a red heat it is rendered brown; it still retains its fibrous structure, but the fibres have become brittle, and easily reducible to powder. By this treatment it loses 29·66 per cent., consisting of pure water.

It dissolves in nitric acid without effervescence, leaving silica. I found its constituents,

		Atoms	
Magnesia,	51·721	20·69	17
Silica,	12·568	6·28	5·16
Peroxide of iron,	5·874	1·17	0·96
Water,	29·666	26·33	21·63
	99·829		

These numbers are nearly equivalent to

5 atoms silicate of magnesia,
11 atoms bihydrate of magnesia,
1 atom ferrate of magnesia.

Were the ferrate of magnesia to be considered as accidental, nemalite would be $MgS+2MgAq^2$.

Sp. 11. *Nephrite.*†

Hydrous sesquisilicate of magnesia.

The term *nephrite* has been applied by mineralogists to minerals possessing very different characters, and therefore belonging to distinct species. The mineral to which I mean to confine the name here, is found on the sea-shore of Icolmkill, in water-worn nodules, having been originally disseminated through a limestone, which has long ago been wrought out. But I have specimens from North America, which, though much whiter, possess the same characters, and yield the same constituents when analyzed. Several of the rocks distinguished by the name of serpentine, possess the same chemical constitution, though more or less contaminated with foreign matter. Indeed it will appear immediately that nephrite and serpentine constitute only one species.

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* Silliman's Jour., iv. 19.

† From νεφρος, the kidney; because it was considered as a cure for diseases of the kidney.

Colour leek green, of very different degrees of intensity in different parts of the mineral, which, in consequence, appears mottled.

Massive and compact without any visible cleavage; fracture splintery; feel soapy; lustre resinous; brittle; hardness 3·5; specific gravity 2·595.

Infusible per se before the blowpipe: with biphosphate of soda fuses into an opaque white bead.

A translucent light-coloured specimen from Iona, yielded

		Atoms.	
Silica,	44·85	22·42	1·55
Magnesia,	36·05	14·42	1
Protoxide of iron,	3·60	0·80	0·05
Alumina,	1·30	0·57	0·03
Water,	13·55	12·04	0·82
	99·35		

In the nephrite from Hoboken, which is white, the oxide of iron is wanting. I am therefore disposed to consider it in the Iona specimens as accidental. If this be so, nephrite is a compound of

1 atom sesquisilicate of magnesia,
1 atom water.

It is therefore a hydrous sesquisilicate of magnesia.

The following table exhibits the constituents of a specimen of common yellow-coloured serpentine from Hungary. Its specific gravity was 2·8.

			Atoms.
Silica,	28·75	14·375	2
Alumina,	6·45	2·86	
Peroxide of iron,	3·05	0·61	
Magnesia,	33·10	13·24	2
Lime,	5·18	1·48	
Water,	24·25	21·55	3
	100·88		

If we include the lime we perceive that the mineral is a silicate of magnesia; but the water is more than in nephrite.

Nephrite is $MgS^{1\frac{1}{4}}+1Aq.$; but the common serpentine is $1MgS+1\frac{1}{2}Aq.$ The alumina and peroxide of iron are doubtless accidental.

Another specimen of common serpentine, also yellow, and from Zeoblitz, and having a specific gravity of 2·412, was composed of

		Atoms.	
Silica, . .	38·95	19·475	14.5
Magnesia, . .	39·80	15·92	11·88
Peroxide of iron with trace of alumina,	6·70	1·34	1
Water, . .	14·00	12·4	9·25
	99·45		

Here $2\frac{1}{2}$ atoms of silica appear to be united with 1 atom of peroxide of iron and alumina. This being abstracted the mineral is very nearly $MS+1Aq.$

From these and two or three other analyses which I made, common serpentine seems in general to be nothing else than a hydrous silicate of magnesia.

Sp. 12. *Precious Serpentine.*

Hydrous sesquisilicate of magnesia, picrolite.

The name *serpentine* or *ophites*, has been long applied by mineralogists to a species of rock distinguished by a remarkable variety of colours, which gave it a fancied resemblance to the skin of a serpent. The *precious serpentine*, so named from its superior beauty, seems to have been constituted a peculiar species first by Werner. Haussmann, during his journey through Sweden in 1813, first described a mineral to which he gave the name of *picrolite*, and which he says occurs in different parts of Sweden. It is obvious, both from his description and from the analysis of picrolite, that it is identical with the precious serpentine of Werner.

Colour various shades of green, particularly leek green and mountain green, also dirty straw yellow.

The texture is compact, and the fracture conchoidal.

I have never seen any specimen which had the least tendency to a regular form; but Dr. Fowler assures us that in the township of Warwick, Orange County, New York, crystals of it occur from twelve to sixteen inches in circumference. They are four-sided prisms, slightly oblique. They are often greenish, but sometimes yellow, with an admixture of hydrated magnesia.[*]

Lustre resinous, inclining to pearly; translucent on the edges; hardness 3·5; specific gravity 2·591.

Before the flame of the blowpipe, in the platinum forceps, it assumes a brownish red colour, but does not fuse. With borax it fuses with difficulty into a green glass, which becomes almost white on cooling. With biphosphate of soda it melts with difficulty into a glass tinged with iron. With carbonate of soda it fuses into a yellowish brown enamel.

The following table exhibits the result of four different analyses of this mineral; the first three were of the picrolite of Haussmann, the last of precious serpentine.

	†	‡	§	‖
Silica,	40·04	41·660	45·804	43·07
Magnesia,	38·80	37·159	39·664	40·37
Lime,	—	——	——	0·50
Alumina,	—	——	0·920	0·25
Protoxide of iron,	8·28	4·046	2·000	1·17
Protoxide of manganese,	—	2·247	——	—
Water,	9·08	14·723	12·52	12·45
Carbonic acid,	4·70	——	——	—
	100·9	99·838	100·908	97·81

The following table exhibits the analyses of a considerable number of serpentines from different localities. The nine first by Lychnell,[¶] the tenth by Mosander.[**]

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[*] Annals of Philosophy (second series), x. 314. Are not these rather crystals of killinite than of serpentine?

[†] Almroth, Afhandlinger, vi. 267.

[‡] Stromeyer; Untersuchungen, p. 365. The specimen was from Philipstad, in Wermeland.

[§] By my analysis. The specimen was a picrolite sent me by M. Swedensjierna.

[‖] Hisinger Afhandl. iv. 341. The specimen was a precious serpentine from Skyttgruvan, Fahlun.

[¶] Kong. Vet. Acad. Handl. 1826, p. 175.

[**] Ibid. 1825, p. 227.

	*	†	‡	§	‖	¶	**	††	‡‡	§§
Silica, . . .	41·95	40·98	41·58	42·16	43·20	41·67	42·01	41·66	35·28	42·34
Magnesia, . .	40·64	33·44	42·41	42·26	40·09	41·25	38·14	40·64	35·35	44·20
Lime, . . .	—	trace	—	—	—	—	3·22	0·31	—	—
Alumina, . .	0·37	0·73	trace	—	—	—	—	0·70	13·73	—
Protoxide of iron, .	2·22	8·72	2·17	1·98	5·24	1·64	1·30	2·11	1·79	0·18
Protoxide of manganese,	—	—	—	—	—	—	trace	—	—	—
Protoxide of cerium,	—	—	—	—	—	—	2·24	1·25	—	—
Carb. acid and bitumen,	3·42	1·73	2·38	1·03	—	1·37	0·19	0·13	6·28	0·87
Water, . . .	11·69	12·86	11·29	12·33	11·42	13·80	12·15	12·93	7·33	12·38
	100·28	98·46	99·83	99·76	99·95	99·73	99·25	99·73	99·76	99·97

If we leave out Almroth's analysis in the first table, because the specimen seems to have been impure, the mean of the other three gives us

1·4 atoms silica,
1 atom magnesia,
0·74 atom water.

But as it appears from Lychnell's analyses, and those of Almroth and Mosander, that serpentine is scarcely ever free from carbonic acid, we may perhaps without any sensible error, consider the ratio of the atoms of silica and magnesia to be 1½ : 1. The water present amounts only to ¾ths of an atom. But as all the specimens examined had been long exposed to the atmosphere, they might perhaps have sustained a loss of water. Hence I am disposed to consider the constitution of precious serpentine to be

1½ atom silica,
1 atom magnesia,
1 atom water,

And its formula will be $MgS^{1\frac{1}{2}}+Aq$.

The mean of the ten analyses given in the second table, leaving out the 9th, which obviously belongs to another mineral, gives us

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* Precious serpentine from Skyttgruvan at Fahlun.

† Radiated Picrolite from Taberg.

‡ A yellow translucent serpentine from Sjögruvan in Svärdsjo.

§ Common serpentine from Sala.

‖ Green radiated serpentine from Massachusetts.

¶ Marmolite from Hoboken.

** A very light yellow serpentine from Hvittis in Finland; translucent when in thin plates.

†† A dark yellow and slightly translucent serpentine from Ozen in Norberg.

‡‡ A so called serpentine from the lime quarry of Oker. Light grey yellow, and translucent.

§§ From the limestone quarry of Gullsjo in Wermeland. Almost colourless; but here and there having a tint of apple green. Sp. gr. 2·52.

1·35 atom silica,
1 atom manganese,
0·7 atom water.

But the mean quantity of carbonic acid obtained in these 9 analyses, is 1·23 equal to 0·02 atom, supposing the magnesia present to amount to one atom. This will raise the silica to 1·37 atom, and the water to 0·715. So that the results of these analyses do not differ much from those of the preceding.

From these analyses compared with the preceding analysis of nephrite, it is clear that precious serpentine and nephrite constitute in fact only one species. The *metaxite* of Breithaupt is also a variety of serpentine. The following is the description of *metaxite*.

Colour greenish white; lustre inclining to silky.

Texture fibrous; seemingly composed of a congeries of oblique prisms about half an inch long, and attached to each other without any cement. The faces of these prisms measured by the common goniometer, meet at angles of 99° and 81°. In the specimen in my possession, there are four sets of such prisms following each other in succession, as if the specimen were divisible into four successive plates (each half an inch thick). I believe this appearance to be an ocular deception; for on breaking off some of the prisms, those between them were seen passing, without interruption, from one end of the specimen to the other.

Rather sectile.

Hardness 3·5; specific gravity 2·4212.

Before the blowpipe it fuses without communicating any colour to the flame. When heated in a glass tube, it gives out pure water. With carbonate of soda it fuses into a white bead. With biphosphate of soda it fuses slowly, leaving a silica skeleton. When strongly ignited with nitrate of cobalt it assumes a lilac colour, showing the presence of magnesia.

It was subjected to analysis by my son, who obtained

		Atoms.	
Silica,	45·04	22·52	1½
Magnesia,	34·00	12·4	1
Peroxide of iron,	5·28	1·05	
Water,	15·40	13·68	1
	99·72		

It is therefore obviously a compound of

1½ atoms silica,
1 atom magnesia (including the iron),
1 atom water,

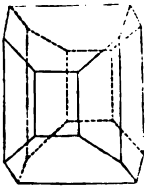
Or it is a hydrous sesquisilicate of magnesia.

Sp. 13. *Picrosmine.*

Dihydrous bisilicate of magnesia.

This mineral was constituted into a species by Haidinger, who named it from the peculiar smell which it exhales when moistened.* The only locality hitherto known, is the iron mine called Engelsborg, near Presnitz in Bohemia.

Colour greenish white, passing into greenish grey and mountain green; sometimes oil, leek, and blackish green. Streak white, dull.



Fracture uneven; scarcely perceptible.

Crystallizes in octahedrons with scalene triangular faces. The figure in the margin represents the most usual crystal.

Lustre pearly; hardness 2·5 to 3; varies from translucent on the edges to opaque.

Specific gravity from 2·596 to 2·660.

Before the blowpipe infusible per se, but gives out water; becomes first black, then white and opaque, and acquires a hardness equal to 5. Fuses with biphosphate of soda, leaving a silica skeleton. With nitrate of cobalt it assumes a pale red colour.

Its constituents, as determined by Magnus, are as follows:

		Atoms.
Silica,	54·886	27·443
Magnesia,	33·348	13·34
Alumina,	0·792	0·35
Peroxide of iron,	1·399	0·28
Protoxide of manganese,	0·420	0·09
Water,	7·301	6·5
	98·146†	

It is obvious that the constitution of this mineral is

2 atoms silica,	4
1 atom magnesia,	2·5
½ atom water,	0·5625
	7·0625

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* From πικρὸς, *bitter*, and οσμὴ, *odour*.

† Poggendorf's Annalen, vi. 53.

About seven years ago, I received an American mineral from Mr. Nutall, which is very intimately connected with picrosmine.

Colour white, with a slight shade of green.

The specimen is composed of a congeries of prismatic crystals very irregularly disposed, and so involved in each other that the shape cannot be accurately determined. They seem to be four-sided oblique prisms.

Lustre vitreous; translucent on the edges; crystals cleave longitudinally; hardness 3·5; specific gravity 2·976.

Its constituents were

		Atoms.
Silica,	56·64	28·32
Magnesia,	36·52	14·6
Alumina,	6·07	2·7
Protoxide of iron,	2·46	0·54
	101·69	

If we admit the alumina and protoxide of iron to be accidental ingredients, the mineral will be an anhydrous bisilicate of magnesia. The only difference between it and picrosmine is the absence of the half atom of water which the latter contains.

Sp. 14. *Schiller spar.*

Hydrous bisilicate of magnesia, karstin, otrelite—diallage metalloide, foliated ?

This mineral has only been met with hitherto at Baste, in the forest of Harzburg in the Hartz. It was first noticed by Von Trebra, in 1783, in his mineralogical description of the Hartz. Since that period a great deal has been written on it, and it has been admitted into most mineralogical systems; but both its description, and the historical details concerning it, are so full of inaccuracies that it would be hazardous to notice them. By far the best account of it which has appeared is by Dr. F. Köhler of Cassel.

Schiller spar occurs in a rock which is generally considered as a serpentine. It has a dark green colour, an uneven and splintery fracture; is translucent when in thin plates; its hardness is 3·75; it is sectile, and has a specific gravity of 2·668. Besides schiller spar it contains crystals of augite, and rounded particles of compact felspar.

The schiller spar occurs in it in broad foliated masses, which cleave in two directions, one of which is highly perfect and easily obtained, while the other appears only in slight traces.

These cleavages give a rhombic prism for the shape of the primary crystal, with angles of about 93° 30′, and 86° 30′, but the base of the prism has not yet been obtained.

Lustre metallic pearly, and considerable upon the perfect faces, indistinctly vitreous upon the other faces.

Colour olive green and blackish green, inclining to pinchbeck brown upon the perfect faces of cleavage; streak greyish white, inclining a little to yellow.

Very sectile; hardness 3·75; specific gravity, as determined by Köhler, 2·652; translucent on the edges.

Before the blowpipe, in the platinum forceps, it loses its green colour, and becomes tomback brown, the lustre inclining still more to the metallic. Thin pieces thus treated become attracted by the magnet. It does not melt, but the thin edges are rounded off. It gives off water when heated in a glass tube, which exhibits traces of ammonia. When thus deprived of water, its colour becomes tomback brown. With borax it enters into fusion with difficulty; it shows the presence of iron, and the bead on cooling becomes slightly emerald green, in consequence of the presence of chromium. With biphosphate of soda it exhibits the same phenomena, and leaves a silica skeleton. With carbonate of soda it does not fuse, but exhibits on platinum foil the presence of manganese.[*]

The constituents of schiller spar, as determined by the analysis of Köhler, are as follows:

		Atoms.
Silica,	43·900	21·95
Magnesia,	25·856	10·34
Protoxide of iron and chromium,	13·021	2·89
Protoxide of manganese,	0·535	0·12
Lime,	2·642	0·75
Alumina,	1·280	0·55
Water,	12·426	11·04
	99·660[†]	

If we admit the lime to be united to the same proportion of silica as the magnesia, and the iron, manganese, and alumina to be accidental, the mineral will be a compound of

2 atoms silica,
1 atom magnesia,
1 atom water,

and its formula will be $MgS^2 + Aq$.

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[*] Köhler, Poggendorf's Annalen, ii. 192.

[†] Ibid.

Köhler likewise analyzed the stone in which the schiller spar occurs. The result was as follows:

Silica, ...	42·364
Magnesia, ...	28·903
Protox. of iron, with some chromium,	13·268
Lime, ...	0·627
Alumina, ...	2·176
Protoxide of manganese, . .	0·853
Water, ...	12·071
	100·262

It is at once evident from this analysis that the stone and the schiller spar are identical in their composition, consequently the matrix of schiller spar is not serpentine, but a substance sui generis.

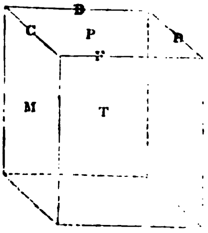
There were three analyses of schiller spar published many years ago, the results of which may be seen in Mohs' Mineralogy, ii. 207. It will be at once evident upon inspecting these analyses, that the minerals analyzed by Heyer and Vauquelin were not schiller spar, but something else; but that Drappier had experimented upon real schiller spar.*

Sp. 15. *Tersilicate of Magnesia.*

Pyrallolite.

This mineral has hitherto been observed only at Storgord, in the parish of Pargas, in Finland, where it occurs in a limestone bed along with felspar, augite, scapolite, moroxite, and sphene. It was first observed by Count Steinheil, and it was first described and analyzed by Nordenskiöld.†

Colour white, inclining to greenish; structure foliated; fracture earthy.



The primary form of the crystals is a doubly oblique prism, in which

M on T 94° 36′
P on T 80°.

The edges B, F are almost always replaced by a face inclined upon T, at an angle of 140° 49′. These two new faces frequently obliterate the face P, and cause the prism to terminate in a bihedral summit. Sometimes the edges C,

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* Jour. de Phys. lxii. 48.

† Bidrag till närmare kennedom of Finlands, &c. p. 21.

D are replaced by a face, making an angle with M of about 138° 30′. The face T is considerably larger than the face M.

Lustre dull; sometimes slightly resinous; opaque, when of a considerable size, but translucent when in thin plates; hardness 3·5 to 4; specific gravity 2·555 to 2·594.

Before the blowpipe it becomes first black, then white again; afterwards it intumesces and melts on the edges into a white enamel. With borax it yields a transparent glass. The addition of nitre shows the presence of manganese. With biphosphate of soda it effervesces a little, and then fuses with very great difficulty. With soda it fuses easily into a transparent glass, having a yellowish green colour.

According to the analysis of Nordenskiöld, its constituents are

		Atoms.
Silica, . .	56·62	28·31
Magnesia, . .	23·38	9·35
Alumina, . .	3·38	1·5
Lime, . .	5·58	1·59
Protoxide of manganese,	0·99	0·22
Peroxide of iron,	0·09	0·018
Water, . .	3·58	3·18
Bitumen and loss, .	6·38	
	100	

The alumina and lime are probably in combination, and the oxides of manganese and iron accidental ingredients. On this supposition, pyrallolite is a compound of

3 atoms silica,
1 atom magnesia,
$\frac{1}{3}$ atom water,

And its formula will be $MgS^3 + \frac{1}{3} Aq$.

Sp. 16. *Hydrous tersilicate of Magnesia.*

Meerschaum—myrzer—kil—kilkeffe.

The term meerschaum is applied by the Germans to different earthy substances, which are employed for making the bowls of the Turkey tobacco pipes. The mineral to which we wish to confine the term is dug up at Eski Scheher, in Natolia. The sale of it supports a monastery of Dervises established near the place where it is dug. It is found in a large fissure, six feet wide, in grey calcareous earth. The workmen assert that it grows again in the fissure, and puffs itself up like froth. When fresh dug it is of the consistence of wax; when thrown on the fire it sweats, emits a fetid vapour, becomes hard, and perfectly white.

Colour snow-white; fracture fine earthy, passing into flat conchoidal; surface smooth, and the grains so fine that they are imperceptible; dull; opaque; hardness 2; after exposure to a red heat 6; specific gravity (after being for some years in my cabinet) 2·127.

The constituents, on analysis, were found to be

		Atoms.	
Silica, . . .	42	21	5·16
Magnesia, . . .	30·5	12·2	3
Water, . . .	23	20·44	5·02
Lime, . . .	2·3	0·65	0·16
Alumina, with trace of manganese,	2·0		
	99·8		

It is obviously composed of

5 atoms silica,
3 atoms magnesia,
5 atoms water.

Another specimen which I got under the name of meerschaum, was obviously a deposite from water. Its colour was yellowish white. It was composed of particles which had a visible size; they were soft, and did not seem quite free from extraneous matter. The specific gravity was 1·3. It yielded to analysis,

		Atoms.
Silica, . .	49·000	24·5
Magnesia, . .	13·480	5·4
Water, . .	20·440	18
Carbonic acid, .	4·560	1·65
Alumina, . .	10·800	4·8
Lime, . .	1·108	0·31
Protoxide of iron,	0·712	0·15
Protoxide of manganese,	0·160	0·03
	100·260	

The constitution of this mineral is quite different from that of the preceding. It is probably a mere mixture. If we abstract the carbonates of lime and magnesia, which it obviously contains, it may be considered as a mixture of

1 atom tersilicate of magnesia,
1 atom tersilicate of alumina,
4 atoms water.

Klaproth analyzed two varieties of meerschaum.* One of his specimens approached the last of mine in its constituents; but the other contained much more silica and much more water. It is obvious that unless we restrict the meaning of the term, as I have done, meerschaum cannot be considered as a chemical compound, but merely a mixture.

Sp. 17. *Magnesite.*

This name is applied by the French mineralogists to *meerschaum;* but there is another mineral which occurs in considerable quantities in thin beds in the marly limestone formations round Paris, to which this name has been given. It has been met with in greatest purity at Coulommiers, about 30 miles east of Paris. It was first described by M. Alex. Brogniart, and analyzed by M. Berthier.†

Colour greyish white; with sometimes a very slight tint of red. When heated it loses its grey red tint, and becomes white.

It is soft, and has a smooth and unctuous feel; but its powder is pretty hard.

It imbibes water easily, and swells out much; becomes feebly translucent, and forms a soft paste without plasticity, similar to jelly.

When exposed to the heat of a porcelain furnace it becomes hard, and exfoliates a little, but does not experience any farther alteration. It exhibits no symptom of fusion, but becomes hard enough to strike fire with steel.

Its constituents, as determined by Berthier, are as follow:

		Atoms.	
Silica,	54	27	2·81
Magnesia,	24	9·6	1
Water,	20·1	17·77	1·85
Alumina,	1·4	0·62	0·06
	99·4		

This approaches pretty nearly to

3 atoms silica,
1 atom magnesia,
2 atoms water.

It is therefore a bihydrous tersilicate of magnesia, and its formula is MgS^3+2Aq.

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* Beitrage, ii. 172.

† Ann. des Mines, vii. 290.

It is obvious that the second specimen of meerschaum, of which the analysis is given in page 177 of this work, is in reality an impure specimen of magnesite. Hitherto meerschaum and magnesite have been confounded, though their composition is essentially different.

M. Berthier has given us the constituents of several other varieties of magnesite, from the environs of Paris, and other localities.* We shall exhibit the results in the following table:

	From Asia Minor.	From Cabanas, near Madrid.	From Saltinelle, Gard.	From St. Ouen, at the foot of Mont Martre.
Silica, .	50	53·8	51	51
Magnesia,	25	23·8	19·8	13·4
Water, .	25	20·0	22	18·2
Alumina,	—	1·2	4·4	17·0
Oxide of iron,	—	—		
Sand, .	—	—	2·8	—
	100	98·8	100·0	99·6

Sp. 18. *Quincite.*†

This name has been applied by M. Berthier to a red-coloured substance which occurs interspersed through a limestone deposite which exists at Mehun, in France; and extends from that town to the village of Quincey, and even beyond it. The limestone the most coloured contains very little *quincite*. It may be obtained in a state of purity by treating the limestone with acetic or dilute muriatic acid.

It is in light flocks, and has a fine carmine red colour. A very moderate heat deprives it of its colour. It becomes first violet, then grey, and at last yellowish white, and at the same time pure water is disengaged. The weaker acids, or the strong acids diluted with water, do not act upon it. The strong concentrated acids act on it imperfectly. Silica is obtained in the gelatinous state, and magnesia and iron are dissolved. Its constituents, as determined by Berthier, are

		Atoms.	
Silica, . .	54 .	27	15·25
Magnesia, .	19 .	7·6	4·29
Protoxide of iron,	8 .	1·77	1
Water, . .	17 .	15·11	8·5
	98		

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* Ann. des Mines, vii. 314.

† Memoires par Berthier, i. 71.

This approaches pretty nearly

4 atoms tersilicate of magnesia,
1 atom tersilicate of iron,
8½ atoms water.

Its formula is $4MgS^3+\underline{f}S^3+8\frac{1}{2}Aq$.

Though this mineral is a double salt, we have been induced to place it here in consequence of the analogy which it has to magnesite and meerschaum.

B. DOUBLE SALTS.

Sp. 19. *Ferro-carbonate of Magnesia.*

Brachytypous lime haloid of Mohs.

This species was first distinguished from *bitter spar* and other similar minerals, by Mohs. It occurs in various places in Salzburg, the Tyrol, and Switzerland; and has also been discovered in Unst, one of the Shetland isles.

Colour white or grey, generally inclining to yellow; also yellow and brown; streak greyish white. Fracture conchoidal; structure foliated.

Usually in crystals. The primary form is a rhomboid, approaching very nearly to that of calcareous spar. But P on P′ is 107° 22′ instead of 105° 5′, as in calcareous spar.

Lustre vitreous, sometimes inclining to pearly on the cleavage faces; hardness 4 to 4·5; specific gravity from 3·001 to 3·112.

From the analysis of this mineral given by Mohs, it would seem that it is a compound of

9 atoms carbonate of magnesia,
1 atom carbonate of lime.

But we have four analyses by Stromeyer of four varieties of this mineral, which give the following results:*

	1.	2.	3.	4.	Berthier.†
Magnesia, . . .	41·06	40·19	42·40	43·44	44.5
Protoxide of iron, .	8·57	10·53	6·47	4·98	4·9
Protoxide of manganese,	0·43	0·49	0·62	1·52	—
Coal, . . .				0·11	—
Carbonic acid, . .	48·94	48·48	49·67	49·93	50·6
	99·00	99·69		99·98	100·0

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* Schweigger's Jahrbuch, for 1827, iii. 219.

† Ann. des Mines (second series), iii. 34.

It is obvious that the carbonate of iron cannot be chemically combined with the carbonate of magnesia; because its quantity is variable.

The constitution of these varieties is nearly as follows:

1. 8 atoms carbonate of magnesia,
   1 atom carbonate of iron.
2. 7 atoms carbonate of magnesia,
   1 atom carbonate of iron.
3. 10 atoms carbonate of magnesia,
   1 atom carbonate of iron.
4. 12 atoms carbonate of magnesia,
   1 atom carbonate of iron.

Is it it not likely that it will be found ultimately to be merely a variety of carbonate of magnesia?

Sp. 20. *Calcareo-carbonate of Magnesia.*

Dolomite—conite—gurhofian—anthraconite—miemite—muricalcite—pearl spar—picrite—tharandite—brown spar (in part)—magnesian limestone.

There can be no doubt that several distinct species are at present confounded together under the names of pearl spar and brown spar; and the external characters of these different species approach so nearly that they can only be accurately distinguished by chemical analysis. The following description applies to the mineral compound of 1 atom carbonate of lime, and 1 atom carbonate of magnesia; usually distinguished by the names of *dolomite* and *magnesian limestone.*

Colour white, generally inclining to red or green. It occurs also green, red, brown, grey, and black, owing to foreign admixtures; streak greyish white.

Fracture conchoidal; structure foliated. Primary form of the crystal a rhombohedron, approaching very nearly to the shape of calcareous spar. But P on P′ is 106° 15′, as was first determined by Dr. Wollaston.

Lustre vitreous, inclining to pearly in some varieties; from semitransparent to translucent; hardness 3·5 to 4; specific gravity from 2·815 to 2·884.

Before the blowpipe it behaves like carbonate of lime.

I analyzed several specimens, both crystallized and granular, and found the constitution to be

1 atom carbonate of lime, .	6·25
1 atom carbonate of magnesia,	5·25
	11·5

This is the case with the magnesian limestone from the neighbourhood of Sunderland. Berthier analyzed eight different varieties of calcareo-carbonate of magnesia, from different localities, and found their constituents as follow:*

	1. St. Briene.	2. Namar.	3. Bruni-quel.	4. Namar.	5. Bour. bonne.	6. Bour-bonne.	7. Esto-von.	8. Schir-mech.
Lime, . . .	44·0	37·6	34·2	29·1	29·2	30·0	10·7	29·5
Magnesia, . .	8·4	13·6	16·2	21·0	21·2	22·4	7·7	20·0
Protoxide of iron, .	—	1·8	—	1·2	—	—	0·8	1·3
Protoxide of mangan.,	—	—	—	—	—	—	0·3	—
Carbonic acid & water,	40·6	45·6	44	46·7	44·6	47·0	18·6	46·4
Foreign matter, .	7·0	0·4	5·2	2·0	5·0	0·6	61·9	2·2
	100·0	99·0	99·6	100·0	100·0	100·0	100·0	99·4

It is obvious that the 4th, 5th, 6th, 7th, and 8th of these minerals were compounds of

1 atom carbonate of lime,
1 atom carbonate of magnesia.

The first was a compound of

4 atoms carbonate of lime,
1 atom carbonate of magnesia.

The second of

2 atoms carbonate of lime,
1 atom carbonate of magnesia.

And the third of

3 atoms carbonate of lime,
2 atoms carbonate of magnesia.

Nothing very precise can be stated about the geological position of this mineral. It occurs in transition beds, in coal beds, in new red sandstone, in lias, and probably in even newer rocks.

Sp. 21. *Wagnerite.*

Fluophosphate of magnesia.

This mineral has been hitherto found only in short and irregular quartz veins in clay slate in the valley called Höllgraben, near Herpen, in Salzburg. It was noticed in Moll's Ephemerides for 1805.† Professor Fuchs saw a specimen of it in the cabinet of Mr. Wagner, at Munich, and published a description and analysis of it in 1821. He called the mineral Wagnerite, because Mr. Wagner supplied him with the specimen which he subjected to analysis.

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* Ann. des Mines (second series), iii. 27.

† i. 209, as quoted by Fuchs; Schweigger's Jahrbuch, iii. 269.

Colour wine yellow; sometimes orange yellow, or inclining to grey.

Fracture flat conchoidal; sometimes splintery and uneven.

Crystals right oblique prisms, with angles of 94° and 86°. The faces are streaked longitudinally.

Lustre vitreous; translucent; hardness 5 to 5·5; specific gravity 3·13, as determined by Fuchs.

When heated to redness, it loses no weight, and undergoes no alteration.

Before the blowpipe it fuses with great difficulty into a dark greenish grey bead. With borax it fuses easily into a transparent glass, yellowish green while hot, but colourless when cold. With biphosphate of soda it behaves almost in the same way. With carbonate of soda it effervesces, but does not dissolve, though it is decomposed. When the assay is dissolved in water a yellowish white powder remains undissolved, which dissolves readily in sulphuric acid, and which consists chiefly of magnesia.

According to the analysis of Fuchs, wagnerite is composed of

		Atoms.
Phosphoric acid, . .	41·73	. 9·26
Fluoric acid, . . .	6·50	. 5·2
Magnesia, . . .	46·66	. 18·66
Protoxide of iron, . .	5·00	. 1·11
Protoxide of manganese,	0·50	. 0·11
	100·39	

If the fluoric acid, oxide of iron, and oxide of manganese, were accidental ingredients, wagnerite would be a diphosphate of magnesia, or a compound of

1 atom phosphoric acid,
2 atoms magnesia.

If the fluoric acid be an essential constituent, it is not so easy to form a distinct notion of the nature of the combination.

Sp. 22. *Chondrodite.*[*]

Fluosilicate of magnesia—maclurite—brucite.

This mineral was first described and analyzed by Count D'Ohsson, in the Memoirs of the Stockholm Academy for 1817, (p. 206). It had indeed been discovered several years before, by Dr. Bruce, imbedded in calcareous spar at Newton,

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[*] From χονδρος, a grain: so named from its granular structure.

Sussex county, in New Jersey; but was mistaken for sphene. Berzelius recognised the identity of the American and Finland mineral, which had been analyzed by D'Ohsson, and confirmed his opinion by an analysis. In 1822 it was again analyzed by Mr. Seybert, who detected fluoric acid in it, and gave it the name of maclurite.*

The colour of chondrodite is wine yellow. The fracture is small conchoidal. But it cleaves, according to Hauy, parallel to the faces of a right oblique prism, the greater angle of which is 112° 12′. He even describes and gives a figure of a six-sided prism of this mineral from the United States. Though I have a number of specimens of it from New Jersey, none of them exhibits any traces of crystallization.

Lustre vitreous; translucent; hardness 4·5; specific gravity of the Finland variety, as determined by D'Ohsson 3·18; by Haidinger 3·199; Seybert states that of the New Jersey variety to vary from 3·157 to 3·228. I found that of the purest specimens I could select 3·118.

Infusible per se by the blowpipe; but becomes darker coloured. With carbonate of soda on charcoal it fuses with difficulty into a light grey slag. With borax it effervesces a little, and fuses easily into a yellowish green glass. With biphosphate of soda it leaves a silica skeleton.

The following table exhibits the constituents of this mineral as determined by analysis:—

	†	‡	§
Silica,	38·00	32·666	36·00
Fluoric acid,	—	4·086	3·75
Magnesia,	54·00	54·000	54·64
Peroxide of iron,	5·10	2·333	3·97
Alumina,	1·50	—	—
Potash,	0·86	2·108	—
Water,	—	1·000	1·62
	99·46	96·193	99·98

This gives (assuming my analysis)

18 atoms silica,
3 atoms fluoric acid,
21·85 atoms magnesia,
0·79 atom peroxide of iron.

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* Silliman's Jour., v. 336.

† D'Ohsson, Kong. Vet. Acad. Handl., 1817, p. 206.

‡ Seybert; Silliman's Jour., v. 336.

§ By my analysis.

If the peroxide of iron be admitted to have been in combination with magnesia, it is evident that chondrodite is a compound of

6 atoms silicate of magnesia,
1 atom fluate of magnesia.

I could discover no potash in chondrodite, though I searched for it.

The only localities of chondrodite at present known are Ersby, in the parish of Pargas, in Finland, imbedded in limestone, and Newton, Sussex, New Jersey, where it is likewise imbedded in calcareous spar.

Sp. 23. *Potash Bisilicate of Magnesia.*

This substance was observed in the quarries of St. Yrieix, and first described and analyzed by M. Le Play.*

It occurs both crystallized and in an earthy state.

Colour yellowish white. The crystals resemble those of tremolite; but the prisms are more oblique than those which constitute the primary form of amphibole. The cleavage parallel to the base is indistinct.

Friable and easily reduced to fine soft powder; specific gravity 2·87.

It has considerable resemblance to steatite in its characters.

The constituents, as determined by M. Le Play, are as follow:—

	Crystals.	Earthy variety.
Silica,	58·16	58·50
Magnesia,	26·48	33·12
Potash,	6·32	5·74
Peroxide of iron,	7·60	1·04
Alumina,	0·40	trace
Lime,	0·64	1·20
Water,	0·40	—
	100·00	99·60

If we take the second analysis, which seems the most accurate, it is obvious that the mineral consists of bisilicates, and nearly in the proportion of

13 atoms bisilicate of magnesia,
1 atom bisilicate of potash.

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* Ann. des Mines (second series), v. 187.

The peroxide of iron and lime differing in quantity so much in the two analyses, must be accidental ingredients.

Sp. 24. *Venetian Talc.*

This mineral is found imbedded in serpentine in the mountains of Salzburg and the Tyrol, and was formerly carried to Venice as an article of commerce, being employed in medicine. Hence the name Venetian talc. It was chiefly employed as a cosmetic. It was reduced to a fine powder by heating it to redness, and afterwards pounded in a hot mortar. I have specimens also from Marlborough, Vermont, United States.

Colour apple green. It is composed of thin flexible plates, having a silvery appearance and a pearly lustre, and easily separable from each other. These plates are not elastic.

I have never seen a specimen of true Venetian talc in crystals.

Lustre pearly and splendent; from semitransparent to translucent; very sectile; hardness 1; specific gravity 2·697.

Infusible before the blowpipe per se.

Its constituents, determined by analysis, are as follow:—

			Atoms.
Silica,	62·588	31·29	5
Magnesia,	30·528	12·21	1·95
Protoxide of iron,	3·848	0·85	0.13
Water,	3·400	3·02	0·48
	100·364		

It is obvious, that Venetian talc is a compound of
1 atom bisilicate of magnesia,
1 atom tersilicate of magnesia,
½ atom water.

What is called *talc slate* agrees in its chemical constitution with Venetian talc, but is not quite so pure. A specimen of this mineral from Novorda, in Piedmont, in my cabinet, possesses the following characters:—

Colour white, with a slight shade of yellow; massive and slatey; composed of impalpable particles; fracture flat conchoidal; opaque, or only translucent on the edges; sectile; lustre silky; hardness 2 to 2·5; specific gravity 2·877. Its constituents, as determined by analysis, are as follow:—

		Atoms.	
Silica,	57·560	28·78	5·19
Magnesia,	27·216	10·88	2
Lime,	7·944	2·27	0·41
Alumina,	1·720	0·76	0·14
Protoxide of iron,	4·716	1·04	0·19
Water,	1·600	1·42	0·26
	100·756		

We see that it is anhydrous, (or contains no chemically combined water,) and that its constitution is the same as that of Venetian talc, though it is mixed with a little impurity, consisting of silica, lime, alumina, and protoxide of iron.

Swedish potstone which has a specific gravity of 2·88, is a mixture of Venetian talc with a black substance in small crystalline grains.

Its constituents were

		Atoms.
Silica,	49·01	5
Magnesia,	30·20	2½
Protoxide of iron,	11·40	½
Alumina,	6·08	½
Water,	4·20	¾

Obviously a mixture of talc and a mineral composed of

1 atom magnesia,
1 atom alumina,
1 atom protoxide of iron,

Sp. 25. *White Augite.*[*]

Diopside, mussite, alalite, sahlite, malacolite.

The specimens of this mineral in my cabinet are from the United States. But it occurs also in Finland, in Sweden, and doubtless in many other places.

Colour white or grey, generally with a slight shade of green.

Texture foliated. It is always crystallized in pretty long four-sided prisms slightly oblique. In no specimen in my possession can the termination of the prisms be observed. But the cleavage shows that it is oblique. Fracture conchoidal.

Cleaves parallel to the faces of a doubly oblique prism.

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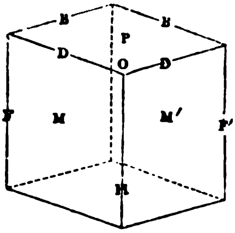
[*] Augite, named from αυγη, *lustre;* because its lustre is much greater than that of hornblende.



P on M or M′ 101°
M on M′ 87° 5′

In the common crystals M is at least double the size of M′. The edge H is always replaced by a tangent plane. Sometimes the edge F′ is also replaced by a tangent plane; but the edge F is usually entire. In the variety called diopside, found in the Piedmontese Alps, the edge H is replaced by three planes, the edge F′ by a tangent plane, and the terminal edges of the prism are also replaced by planes, which cause the prism to terminate in a truncated four-sided pyramid. Finally, the solid angle O is replaced by a small tangent plane.

Lustre vitreous, usually translucent, sometimes transparent; refracts doubly very powerfully; hardness 4·75; specific gravity 3·297; that of diopside, as determined by Tonnellier, 3·2374;* that of sahlite, as determined by D'Andrada, 3·2307.

Before the blowpipe it fuses per se into a colourless glass. With borax it fuses readily into a diaphanous glass. With biphosphate of soda it decomposes slowly and leaves a silica skeleton. With carbonate of soda it fuses into a transparent glass.

We are indebted to M. H. Rose† for an elaborate analysis of this species, and of several other minerals hitherto confounded together under the common name of pyroxene. The following table exhibits the result of the most accurate analyses hitherto made.

	‡	§	‖	¶	**	††	‡‡
Silica, ...	54·64	55·32	54·83	55·40	53	54·18	57
Lime, ...	24·94	23·01	24·76	15·70	20	22·72	16·5
Magnesia, . .	18·	16·99	18·55	22·57	19	17·81	18·25
Protox. of mangan,	2·00	1·59	—	0·43	4	1·45	6·00
Peroxide of iron,	1·08	2·16	0·99	2·50	—	2·18	
Alumina, . . .	trace	—	0·28	2·83	3	—	—
Water, . . .	—	—	0·32	—	—	1·20	—
	100·66	99·07	99·73	99·43	99	99·56	97·75

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* Jour. des Mines, xx. 67. † Kong. Vet. Acad. Hand. 1820, p. 325.

‡ From Orrijervi, Finland. Analyzed by Rose. Ibid.

§ Colour yellowish. From Langbanshyttan, Wermeland. Rose. Ibid.

‖ From Tammare in Finland. Bonsdorf's analysis. Ibid.

¶ From Pargas, analyzed by Nordenskiöld, Bidrag, p. 70.

** Sahlite; Vauquelin, Hauy, iv. 382.

†† Sahlite; Hisinger Afhandlingar, iii. 300.

‡‡ Diopside; Laugier, Ann. de Mus. d'Hist. Nat. ii. 157.

It is obvious that the three first of these analyses are identical, and show that the mineral is a compound of

1 atom bisilicate of lime,
1 atom bisilicate of magnesia,

So that the formula for white augite is $\text{CalS}^2+\text{MgS}^2$.

But the analysis in the 4th column is equivalent with

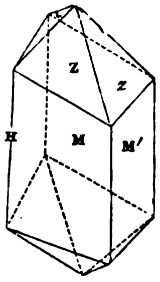
		Atoms.
Silica, . . .	27·7	. 6·205
Lime, . . .	4·48	. 1
Magnesia, . .	9·02	. 2·013
Protoxide of manganese,	0·09	. 0·020
Protoxide of iron, .	0·55	. 0·127
Alumina, . .	1·25	. 0·279

This is obviously

1 atom bisilicate of lime,
2 atoms bisilicate of magnesia,

With a small admixture of disilicates of alumina and iron. The composition is therefore essentially different from that of white augite. We shall therefore give a description of this mineral as it has been drawn up by Nordenskiöld.

The colour is light bluish green. It is always in crystals.



The most common form is a four-sided prism, whose faces M, M′ are inclined at angles of 87° 33′ and 92° 27′. The crystal has an oblique cleavage in the direction of the greater diameter of the prism, which makes an angle of 106° 0′ 30″ with the axis of the prism. The prism terminates in a four-sided pyramid in which

M on Z 134° 46′

Most commonly the obtuse edges of the prism H are replaced by tangent planes which render the prism six-sided.

The specific gravity is 3·267.

Fracture splintery and small conchoidal. Hard enough to scratch glass, but it is scratched by quartz.

The action of the blowpipe is nearly the same as upon white augite.

It must be admitted that both the crystalline form, and the other characters of this mineral, agree very closely with those of common white augite. The form of the crystal, however, though deducible from the primary crystal of augite, is one which I have never seen white augite assume.

The fifth and sixth minerals whose analyses were given in the preceding table, are sahlites; so named because they occur in the lead mine of Sahla in Sweden. Sahlite has a greenish grey colour, and is seldom in regular crystals, but readily admits of cleavage in the direction of the faces of the primary form of white augite. In chemical composition it agrees with white augite, excepting that there is a slight deficiency of lime.

In the analysis of the diopside which constitutes the last column of the table, there is a deficiency of 2¼ per cent. To this perhaps we are to ascribe the apparent excess of silica. There is present 1 atom of tersilicate of iron, and the rest of the constituents constitutes very nearly

$$3CS^2+5MS^2.$$

Thus the constitution of diopside does not exactly agree with that of white augite.

The colour of diopside is light green. It is transparent, and has a specific gravity of 3·310. In its crystalline form it agrees with white augite. It occurs in veins traversing serpentine at Mussa, in Piedmont.

Sp. 26. *Pyroxene.**

Augite, baikalite, coccolite, euchysiderite? fassaite, pentaclusite, pyrgom, vulcanite, asbestus in part.

Under the name *pyroxene* is at present placed a great number of substances which occur in crystals and have the crystalline form of white augite, though they do not agree with that mineral in their composition.

The colour is usually green, or green inclining to brown; sometimes black. The streak is white.

The fracture is conchoidal, and the crystals, which are usually in four or six-sided oblique prisms, cleave parallel to the faces of a rhomboidal prism, having the same shape as the primary form of white augite.

Lustre vitreous, inclining to resinous.

Sometimes translucent, but frequently also opaque.

Hardness 4·75; specific gravity from 3·233 to 3·349.

Before the blowpipe it behaves like white augite, excepting that the colour of the bead is affected by the great proportion of iron which it contains.

The following table exhibits the composition of several of these varieties, as determined by the analysis of H. Rose.†

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* From πυρ, *fire*, and ξενος, *a stranger*; because it occurs in lava; to which Hauy considered it as not belonging.

† Kong. Vet. Acad. Hand. 1820, p. 329.

	*	*	†
Silica, . .	54·08	54·55	53·36
Lime, . .	23·47	20·21	22·19
Magnesia, . .	11·49	15·25	4·99
Protoxide of iron,	10·02	8·14	17·38
Protoxide of mangan.,	0·61	0·73	0·09
Alumina, . .	——	0·14	——
	99·67	99·02	98·01

The first of these has the same constitution as white augite; with this remarkable difference, that one-third of the bisilicate of magnesia is replaced by bisilicate of iron. The atomic numbers are,

Bisilicate of lime,	6·7 atoms
Bisilicate of magnesia,	4·6
Bisilicate of iron,	2·2

This is obviously equivalent to

1 atom bisilicate of lime,
1 atom bisilicate of magnesia and iron.

The formula will be

$$\mathrm{Cal}S^2+(\tfrac{2}{3}Mg+\tfrac{1}{3}\underline{f})S^2.$$

We might also consider this mineral as a compound of

2 atoms white augite,
1 atom hedenbergite.

And this in all probability is its true constitution.

The second of the pyroxenes analyzed is also composed of bisilicates, and in this respect agrees with white augite. The atomic quantities of these are

Bisilicate of lime,	5·77 atoms
Bisilicate of magnesia,	6·1
Bisilicate of iron,	1·8

The greatest part of the mineral was white augite. It was composed of

White augite, .	5·77 atoms
Bisilicate of magnesia,	0·43
Bisilicate of iron, .	1·8

Bisilicate of magnesia is the mineral already described under the name of *picrosmine*. Bisilicate of iron has not hitherto been met with native, but it constitutes a common slag; and Mitcherlich informs us, that he has observed it crystallized and having exactly the form of pyroxene. Hence it is not surprising that it should occur mixed in an impure augite without altering the form of the crystal.

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* Both specimens from Björnmyresveden, in Dalecarlia. Colour green.

† From Taberg, in Wermeland. Colour black.

The third of the pyroxenes whose constituents are given by Rose, differs from the other two in this respect, that it is not constituted of bisilicates; or at least there is a surplus of silica, as will appear by stating the atomic weight of the different constituents:

Bisilicate of lime, . .	6·34 atoms
Bisilicate of magnesia, .	2
Bisilicate of iron, .	3·86
Surplus of silica, .	2·28

It might be considered as containing

2 atoms white augite,
3·86 atoms hedenbergite,
0·48 atoms bisilicate of lime,
2·28 atoms silica.

The bisilicate of lime is the well known mineral called *table spar*.

Thus the black augite from Taberg might be a mixture or compound of

1 atom table spar,
4 atoms white augite,
8 atoms hedenbergite,
4½ atoms silica.

Rose has placed hedenbergite among the pyroxenes; probably because, like white augite, it consists of bisilicates; but as its crystalline form and its constituents differ essentially from those of white augite, it ought undoubtedly to constitute a peculiar species.

Sp. 27. *Jeffersonite.*[*]

This mineral was discovered in the beds of iron ore at Franklin, in New Jersey, by Mr. Keating and Mr. Vanuxem, and an account of it was published by the former of these gentlemen in the year 1822.[†]

It occurs in lamellar masses, which were described as not larger than a pigeon's egg; but a specimen in my cabinet, for which I am indebted to the kindness of Dr. Torrey of New

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[*] From Mr. Jefferson, of Virginia, formerly President of the United States of America.

[†] Edinburgh Phil. Jour. vii. 317.

York, is at least six inches long, and three inches over in the broadest part.

The colour is dark olive green, passing into brown.

Structure foliated, and according to Keating it admits of being cleaved in various directions, so that its primary form is not easily ascertained; but as far as I can make out the form from the specimen in my possession, it seems to approach that of pyroxene very closely.

Lustre between resinous and semimetallic; streak grey; powder light green.

Hardness 4·5; specific gravity from 3·51 to 3·55; slightly translucent on the edges.

Before the blowpipe fuses readily into a dark coloured globule.

Its constituents, as determined by Mr. Keating, who analyzed it twice with almost the same results, are as follow:

		Atoms.
Silica, . . .	56 .	28
Lime, . . .	15·1 .	4·31
Protoxide of manganese,	13·5 .	3
Peroxide of iron, .	10·0 .	2
Oxide of zinc, .	1·0 .	0·19
Alumina, . .	2·0 .	0·88
Moisture, . .	1·0	
	98·6	

If we leave out the oxide of zinc and the alumina, as accidental, it is obvious that Jeffersonite is composed of tersilicates, and the constituents are nearly

4 atoms tersilicate of lime,
3 atoms tersilicate of manganese,
2 atoms tersilicate of peroxide of iron.

Sp. 28. *Amphibole.*[*]

Actinolite, actinote, amianthinite, amianthoid, asbestinite, foliated augite, bissolite, corinthine, green diallage,[†] grammatite, hornblende, blue hyperstene, keraphyllite, keratophyllite, lotalite, pargasite, smaragdite, tremolite, asbestus in part, amianthus.

This mineral was constituted into a distinct species in the very infancy of mineralogy, under the name of *hornblende*—a name originally imposed by the Swedish mineralogists, though it is very difficult to determine what the varieties were to which that appellation was applied.

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[*] From αμφιβαλος, ambiguous, so named by Hauy, because it was at first confounded with the *tourmaline.*

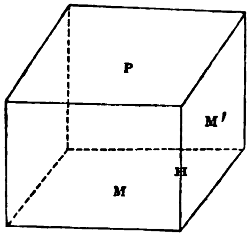
[†] *Green diallage,* according to Haidinger, is a mixture of very thin plates of hornblende and augite.

Hauy proved to the satisfaction of mineralogists in general that the numerous minerals arranged by Werner under the names *tremolite*, *actinolite*, *hornblende*, &c., constitute in fact but one species, as they all possess the same crystalline form. He contrived the general term *amphibole*, which includes them all. But these different varieties are so distinct from each other in their properties, that they cannot be made out by their external characters, if we except the crystalline shape; nor does chemical analysis enable us to subdivide them with accuracy. I am disposed to consider *white tremolite* as the mineral which exhibits amphibole in a state of purity, and shall therefore describe it in the first place.

Tremolite was first observed in the valley of Tremola, in Switzerland: hence the name. Hauy distinguished it at first by the appellation *grammatite*.

Its colour is white, though it frequently has a greenish, bluish, yellowish, or reddish tinge.

It occurs usually in masses composed of delicate crystalline fibres, and likewise in very flat and deeply striated four, six, or eight-sided prisms, rarely terminated by dihedral summits.



It cleaves with brilliant surfaces parallel to the sides of an oblique rhombic prism, in which

P on M or M' 130° 15'
M on M' 124° 30'

Its lustre is vitreous, inclining to pearly on the faces of cleavage.

It is always translucent, at least on the edges; sometimes semitransparent.

Hardness 4·75; exceedingly frangible.

Specific gravity, according to Hauy, varies from 2·9257 to 3·200.

Before the blowpipe it fuses readily, with slight bubbling, into a semitransparent glass. With borax it fuses easily into a colourless transparent glass. With biphosphate of soda it is not decomposed; the assay remains milk-white throughout, and is rounded on the edges; after a long blast the glass becomes opaline on cooling. With a very small quantity of carbonate of soda it fuses into a transparent glass. A larger quantity of the flux causes it to intumesce, and converts it into a white infusible scoria.

We are indebted to Bonsdorf for a very complete analytical investigation of tremolite, and all the varieties of amphibole.*

The following table exhibits the constituents of tremolite, according to the analysis of this excellent chemist:

	†	‡
Silica,	60·31	60·10
Magnesia,	24·23	24·31
Lime,	13·66	12·73
Alumina,	0·26	0·42
Protoxide of iron,	0·15	1·00
Protoxide of manganese,	——	0·47
Fluoric acid,	0·94	0·83
Water,	0·10	0·15
	99·65	100·01

It is obvious at once that these two minerals are identical, as the differences are within the limits of errors in the analysis.

Taking the mean of the two, we have the following atomic quantities:

	Atoms.
Silica,	30·2
Magnesia,	9·7
Lime,	3·77
Alumina,	0·15
Protoxide of iron,	0·12
Protoxide of manganese,	0·10
Fluoric acid,	0·7
Water,	0·11

It is probable that the fluoric acid existed in the mineral in combination with lime or calcium. This supposition would reduce the atoms of lime to 3·07, and the atoms of all the bases, excluding 0·7 atom of fluor spar, amount to 13·14; the atoms of silica being 30·2. Now 30·2 : 13·14 :: 9 : 4 very nearly; while the atoms of magnesia are to those of lime very nearly as 3 to 1. If therefore we exclude the minute quantity of silicated alumina, iron and manganese, as insignificant, it is evident that tremolite is a compound of

1 atom tersilicate of lime,
3 atoms bisilicate of magnesia.

Its formula is $CalS^3+3MgS^2$.

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* Kong. Vet. Acad. Handl. 1821, p. 197.

† Colourless tremolite from Gullsjö. ‡ Yellow tremolite from Fahlun.

That the alumina, oxides of iron and manganese, with their corresponding quantity of silica, may be excluded, is probable from this circumstance that they were much more abundant in the second specimen, which was yellow, than in the first specimen, which was white.

The variety of amphibole distinguished by the names of *actinolite*, *actinote*, and *strahlstein*, from its radiated structure, is very similar to tremolite, except in its colour.

The colour is green of various shades, as leek green, olive green, and emerald green.

It is usually in long thin oblique six-sided prisms, composed of radiating fibres. To mechanical division it yields crystals, having the same primary form as those of tremolite.

When the lustre is vitreous the mineral has much of the aspect of green glass, and is then called *glassy actinolite;* when the lustre is resinous, the mineral is called *common actinolite.*

Usually translucent, at least on the edges; hardness the same as that of tremolite; specific gravity varies from 3·175 to 3·482.

In its other properties it agrees with tremolite. The phenomena before the blowpipe are the same, only the beads are coloured by the iron to which the actinolite is indebted for its green colour. The following table exhibits the constituents of a glassy actinolite from Taberg, analyzed by Bonsdorf:

		Atoms.
Silica,	59·75	29·87
Magnesia,	21·10	8·44
Lime,	14·25	4·07
Protoxide of iron,	3·95	0·87
Protoxide of manganese,	0·31	0·06
Fluoric acid,	0·76	0·60
	100·12	

If we suppose (as before) that the fluoric acid is united to lime, the atoms of lime in the mineral will be reduced to 3·47. The atoms of silica are 29·87, and those of the bases 12·84. Now 29·87 : 12·84 : : 9 : 3·86. This is very nearly as 9 to 4, as in the tremolite; but the proportion of lime is greater than in tremolite, and the protoxides of iron and manganese, taken together, amount to very nearly an atom.

It seems to be $CalS^3+3MgS^2$, (the same as tremolite,) intimately mixed or combined with

$\frac{1}{3}$d atom tersilicate of lime,
$\frac{1}{3}$d atom bisilicate of iron.

What is called *pargasite* is a green coloured mineral which occurs in grains in calcareous spar at Obo, in Finland.

It is translucent, at least on the edges.

Its specific gravity and hardness is the same as that of tremolite. Some of the grains are six-sided prisms, with dihedral summits, and it yields to mechanical division an oblique prism, having precisely the dimensions of the primary form of tremolite.

We have two analyses of this mineral, one by Bonsdorf, and another by C. G. Gmelin. These analyses gave the following results:

Silica,	46·26	51·75
Magnesia,	19·03	18·97
Lime,	13·96	10·04
Alumina,	11·48	10·93
Protoxide of iron,	3·48	3·97
Protoxide of manganese,	0·36	——
Mixed matter,	0·43	——
Fluoric acid,	1·60	1·83
Water,	0·61	
	97·21*	97·49†

Here it is obvious at once that the quantity of silica is less than in tremolite or actinolite. The atoms deduced from the preceding analyses are as follow:

	Bonsdorf.	Gmelin.
Silica,	23·13 atoms	25·87 atoms
Magnesia,	7·61	7·59
Lime,	3·98	3·12
Alumina,	5·10	4·85
Protoxide of iron,	0·77	0·88
Protoxide of manganese,	0·08	
Fluoric acid,	1·28	

In Bonsdorf's analysis, the atoms of silica and alumina together amount to 28·23, and those of the bases to 12·36. Now these numbers are very nearly to each other as 9 to 4; so that if we admit the substitution of a portion of alumina for silica, the acids and bases in pargasite are to each other very nearly as in tremolite and pargasite, though, if we were to abstract a portion of the lime for the fluoric acid, that ratio would not hold. The lime (abstracting 1·28 atom for the fluoric acid) amounts to 2·7 atoms, which is not far from the third of the magnesia, amounting to 7·61 atoms.

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* Bonsdorf. † Gmelin, Kong. Veten. Acad. Handl. 1816, p. 158.

In fact pargasite may be considered as a compound of

$$\mathrm{CalS^3+3MgS^2},$$

but it contains also, either combined or mixed,

0·11 atom silica,
2 atoms alumina,
0·3 atom protoxide of iron,
0·5 atom fluor spar.

The Pargas hornblende, so minutely described by Nordenskiöld, in his Bidrag, agrees, as appears from the analysis of Bonsdorf, almost exactly with pargasite in its composition.

The variety of amphibole called *hornblende* occurs pretty abundantly in greenstone and other trap rocks, and also in syenite, and occasionally in granite. Its colour is dark bottle green, or brownish green, or blackish green. Powder greenish grey. Structure foliated. The primary form of the crystal is the same as that described above, when giving an account of tremolite. Its most common form is a six-sided prism terminated by a low four-sided pyramid, or by three faces. The two additional faces of the prism are produced by the acute edges H of the primary crystal being replaced by tangent planes. Hence the inclination of M′ on the new face is 117° 45′.

The lustre is vitreous, and the crystals are usually opaque, or nearly so. They are uncommonly tough, which was the reason of applying to them the name of hornblende. In other respects hornblende corresponds in its characters with tremolite.

The constituents of hornblende, as determined by Bonsdorf, are as follow:—

Silica,	48·83	42·24	45·69
Magnesia,	13·61	13·74	18·79
Lime,	10·16	12·24	13·83
Alumina,	7·48	13·92	12·18
Protoxide of iron,	18·75	16·26	7·32
Protoxide of manganese,	1·15	0·33	0·22
Fluoric acid,	0·41	trace	1·50
Water,	0·50	—	—
	100·89*	98·73†	99·53‡

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* Black hornblende from Nordmark.

† Black hornblende from Vogelsberg, in Wetteran.

‡ Hornblende from Pargas. It was at first called *basalt*.

If these hornblendes be constitutionally the same as white tremolite, it is obvious that they must be mixed with a great deal of foreign matter.

If the first specimen consist of $CalS^3+3MgS^2$, there must be present in it besides,

Silica,	.	4·47 atoms
Alumina,	.	1·47
Protoxide of iron,		2·24
Fluor spar,	.	0·32
Lime,	.	0·42
		8·92

These foreign bodies constitute almost 9 atoms, or $\frac{9}{22}$ of the whole atoms in the mineral. It will be observed, that the atomic weight of the surplus silica is equal to that of all the surplus bases. Hence they are all simple silicates, with the exception of the lime, which is a bisilicate, and as all these silicates exist, we have no reason to be greatly surprised at finding them mixed, or combined in hornblende with the substance which constitutes white tremolite.

If the second specimen consist essentially of $CalS^3+3MgS^2$, there must be present in it besides

Silica,	.	2·5 atoms
Alumina,	.	3·37
Protoxide of iron,		1·97
Lime,	.	0·91
		8·75

Here also the foreign matter amounts almost to 9 atoms, or to $\frac{9}{22}$ of the whole number of atoms in the crystal. But as the atoms of silica are little more than one-third of the atoms of bases, and as we know no trisilicates of alumina or iron, we cannot consider this foreign matter in any other light than as partly a silicate of alumina, and partly an aluminate of iron and lime, in which the alumina acts the part of an acid.

The third specimen contains hardly any surplus of silica; but

Alumina,	.	2·15 atoms
Protoxide of iron,		0·64

The mineral from Sardinia, well known by the name of *amianthus*, of which incombustible cloth was made by the ancients, is merely a variety of amphibole.

It has a white colour with a slight shade of green, anc silky lustre, and is composed of fine soft flexible threa easily separable from each other, and admitting of being sp into thread. The specific gravity is 1·551. Before the blo pipe it melts into a white bead. Its constituents, as det mined by an analysis in my laboratory, were

Silica, . .	55·908
Magnesia, . .	27·068
Lime, . .	14·632
Alumina, . .	1·820
Protoxide of iron,	6·528
	105·956

The excess is probably owing to the formation of a doul salt of magnesia during the analysis. A bare comparison these constituents with those of white tremolite, will sati the reader that the two minerals belong to the same specie

Common asbestus in general belongs rather to pyroxe than to amphibole.

Sp. 29. *Norwegian Tremolite.**

This mineral was found by M. Nelson in large rocks in t Isle of Tiotten, near the shore of Helgoland, in Norway.

It was in amorphous masses, having a white colour passi into bluish grey. Its lustre is pearly. It is translucent the edges. Structure foliated, and giving by mechani division an oblique prism, with angles of 74° and 106°.

Hardness about 6; specific gravity 3·2.

Before the blowpipe melts with difficulty on the edges.

The constituents of this mineral, as determined by t analysis of C. G. Retzius, are as follow:—

		Atoms.	
Silica, . .	63·7	31·85	8·94
Lime, . .	27·2	7·77	2·18
Magnesia, . .	8·9	3·56	1
	99·8		

This corresponds very nearly with

9 atoms silica,
2 atoms lime,
1 atom magnesia.

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* Ann. des Mines, vi. 250.

Hence the constitution of the mineral must be
2 atoms tersilicate of lime,
1 atom tersilicate of magnesia.

Sp. 30. *Retinalite.*[*]

I received this mineral some years ago from Dr. Holmes of Montreal. Its locality is Granville, in Lower Canada. It was considered in Canada as a variety of serpentine.

Colour brownish yellow.

The specimens as I got them were amorphous masses, having exactly the appearance of lumps of resin. Hence the the reason of the name (from ῥητινη, resin.)

Texture compact; fracture splintery.

Translucent.

Lustre resinous, shining.

Hardness 3·75; specific gravity 2·493.

Before the blowpipe becomes white and friable, but it does not fuse.

With borax it forms a clear colourless glass, a white matter (doubtless silica) occupying the interior of the globule. With biphosphate of soda it fuses into a glass transparent while hot, but becoming white and opaque on cooling. With carbonate of soda it fuses into an opaque bead.

Its constituents were found to be

			Atoms.
Silica,	40·550	20·275	8·62
Magnesia,	18·856	7·54	3·2
Soda,	18·832	4·70	2
Peroxide of iron,	0·620	0·12	0·05
Alumina,	0·300	0·12	0·05
Water,	20·000	17·77	8·41
	99·158		

The constitution is $3MgS^2+2NS+8\frac{1}{2}Aq$.

It is therefore totally different from serpentine. It often contains mixed with it a quantity of carbonate of lime.

Sp. 31. *Hypersthene.*[†]

Labradore hornblende—paulite.

The first specimen of this mineral came from the Island of St. Paul, on the coast of Labradore. Hence it was called *paulite* by Werner, when he constituted it a distinct species in 1812. In that island it occurs chiefly in rolled masses. In that part of the Isle of Skye, called Cuchullin, there is a range of mountains environing a small lake, and composed entirely of hypersthene and felspar. These mountains are uncommonly steep, and quite barren. Hypersthene is found also at Baffin's bay. I have specimens from that locality, for which I am indebted to the kindness of a surgeon of a whale ship, an old pupil.

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[*] Ρητινη, *resin*, from its great resemblance to resin.

[†] From ὑπερ, above, and σθενος, strength, because it possesses greater lustre and hardness than *amphibole*, with which it was confounded.

Colour greyish, or greenish black; sometimes nearly copper red.

It is always crystallized in rhombic prisms, with angles of 93° 30′ and 86° 30′. The base of the prism is wanting in all the crystals that I have seen; nor can any cleavage be observed transverse the axis of the prism. But Mr. Brooke informs us, that he possesses a fragment of a crystal which indicates an oblique termination, inclining upon the acute edge of the prism. Hauy makes the prism a right oblique, and says, that he was able to observe the cleavage parallel to the base by presenting it at night to the light of a candle.

Lustre eminently metallic upon the faces of cleavage; in other directions vitreous.

Opaque, or at most very slightly translucent on the edges.

Hardness 4·75; very difficult to break, nor does it seem to have any tendency to fall to powder, even after long exposure to the atmosphere. The barrenness of the Cuchullin mountains is owing to the entire absence of soil.

The specific gravity of the Isle of Skye hypersthene is 3·338, that of paulite is 3·385, and that from Baffin's Bay 3·355.

Before the blowpipe it is infusible per se, but melts upon charcoal into a greenish grey opaque globule. Dissolves easily in borax.

The constituents of Isle of Skye hypersthene, as determined by the analysis of it by Dr. Thomas Muir in my laboratory, are as follow:—

		Atoms.	
Silica,	51·348	25·67	11·56
Magnesia,	11·092	4·44	2
Protoxide of iron,	33·924	7·54	3·39
Lime,	1·886	0·52	0·23
Water,	0·500		
	98·700		

The atoms of silica are very nearly twice as many as those of the bases. Hence the Isle of Skye hypersthene is composed of bisilicates. If we unite the lime to the magnesia, the atoms of magnesia are to those of protoxide of iron almost exactly as 2 to 3. Consequently the constitution of this mineral is

2 atoms bisilicate of magnesia,
3 atoms bisilicate of iron.

The formula will be $2MgS^2+3\underline{f}S^2$.

Labradore hypersthene, or paulite, was also analyzed by Dr. Muir, who found the constituents,

		Atoms.
Silica,	46·112	23·05
Magnesia,	25·872	10·35
Protoxide of iron,	12·701	2·82
Protoxide of manganese,	5·292	1·18
Lime,	5·380	1·54
Alumina,	4·068	1·76
Water,	0·480	
	99·905	

If we unite the lime and magnesia, and the protoxide of manganese with the protoxide of iron, the atoms of the former will be to those of the latter very nearly as 3 to 1. There is a deficiency of silica to constitute these bases into bisilicates. But Klaproth, in his analysis of paulite, states the quantity of silica which he found at 54·25 per cent., which, if we add to it the alumina, would furnish the requisite quantity. Paulite from this would seem to be composed of

3 atoms bisilicate of magnesia,
1 atom bisilicate of iron.

So that it differs essentially in its constitution from Isle of Skye hypersthene. If this difference hold in future analyses, it will be necessary to constitute each a peculiar species.

The specimen from Baffin's Bay not being so pure as the other two, no dependence can be placed upon it as constituting a type of the species. It was subjected to analysis by the same accurate experimenter, and found composed of

		Atoms.
Silica,	58·272	29·13
Magnesia,	18·960	7·58
Protoxide of iron,	14·416	3·20
Protoxide of manganese,	6·336	1·40
Alumina,	2·000	0·88
	99·984	

The silica is more than sufficient to convert the whole bases into bisilicates. Uniting the oxides of iron and manganese, their atoms are to those of the magnesia very nearly as 3 to 5. Hence the composition of the mineral is

5 atoms bisilicate of magnesia,
3 atoms bisilicate of iron,

with a surplus of

3·11 atoms silica,
0·57 atom alumina.

Probably the specimen contained interspersed grains of quartz, though they could not be distinguished by the eye.

Sp. 32. *Humboldilite.*[*]

This mineral occurs in the lava of Mount Vesuvius, and was described and named by Messrs. Monticelli and Covelli.

The colour is brown, inclining slightly to yellowish or greenish yellow.

Fracture conchoidal.

Primary crystal a right square prism. The lateral edges are frequently replaced by tangent planes, or by two planes converting the crystal into a six, eight, or sixteen-sided prism.

Lustre vitreous; translucent, and in thin laminæ transparent; hard enough to scratch glass; specific gravity 3·104.

Melts before the blowpipe with effervescence, but without forming a globule. With borax it melts into a transparent glass. With biphosphate of soda or carbonate of soda it melts with extreme difficulty into a brown opaque enamel.

Pulverized and treated with nitric acid, it gelatinizes.

Its constituents, according to the analysis of Monticelli and Covelli, are

		Atoms.
Silica, . . .	54·16 .	27·08
Lime, . . .	31·67 .	9·04
Magnesia, . .	8·83 .	3·53
Alumina, . .	0·50 .	0·22
Protoxide of iron, .	2·00 .	0·44
	97·16[†]	

The atoms of silica being very nearly twice as many as those of the bases, it is clear that the mineral is composed of bisilicates. And leaving out the small quantities of bisilicates of alumina and iron, the proportions approach

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[*] Silliman's Jour. ii. 251. The mineral was named, by the Italian mineralogists, in honour of M. Humboldt.

[†] Berzelius in his Jahresbericht for 1833 (p. 169), gives the following analysis of this mineral by Kobell :

3 atoms bisilicate of lime,
1 atom bisilicate of magnesia.

The formula will be $3CalS^2+MgS^2$.

It usually occurs in a lava composed of grains of *zurlite** and pyroxene, both amorphous and having together a greenish brown colour.

Sp. 33. *Hyalosiderite*.†

This mineral was observed by Dr. Walchner in an amygdaloid in the Kaiserstuhl, near Sasbach in Brisgau. He published a description and analysis of it in 1823.‡

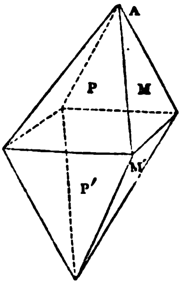
Colour yellowish or reddish brown; streak cinnamon brown; fracture small conchoidal.

It is usually crystallized. The primary form is an octahedron with a rectangular base. The summits A are commonly replaced by planes parallel to the base, and cutting the pyramids so deep, that the crystals have the appearance of thin plates with bevelled edges.

P on P′ 99° 22′
M on M′ 77° 50′

Internal lustre vitreous; of the surfaces metallic; translucent on the edges.

Hardness 5·5; specific gravity 2·875.



		Atoms.
Silica,	49·36	24·68
Alumina,	11·20	5
Lime,	31·96	9·13
Magnesia,	6·10	2·14
Protoxide of iron,	2·32	0·51
Soda,	4·28	1·07
Potash,	0·38	0·06
	105·60	

This would give the mineral quite a different position. But the great excess renders the result doubtful.

Zurlite is a name given by Ramondini to a mineral which occurs in the lava of Mount Vesuvius, along with Humboldilite.

Its colour is asparagus green; its fracture granular; crystalline form the same as that of humboldilite; lustre dull; scratched by the knife, does not scratch glass: specific gravity 2·274. When pulverized and put into nitric acid, it effervesces and then subsides into a greenish imperfect jelly.

It is probably only a variety of humboldilite, or rather a mixture of humboldilite, pyroxene and carbonate of lime.

† From υαλος, glass, and σιδηρος, iron. ‡ Schweigger's Jahrbuch, ix. 65.

Before the blowpipe it becomes black and then melts into a black bead, which is attracted by the magnet. With borax it fuses easily into a clear glass, greenish yellow while hot; but nearly colourless when cold. With biphosphate of soda it forms a greenish glass leaving a silica skeleton.

Its constituents, according to the analysis of Walchner, are

		Atoms.	
Silica,	31·634	15·81	3
Protoxide of iron,	29·711	6·61	1·25
Magnesia,	32·403	12·96	2·46
Alumina,	2·211	0·98	0·12
Protoxide of manganese,	0·480	0·10	0·02
Potash,	2·788	0·46	0·08
Chromium, a trace,			
	99·227		

The atoms of silica being 15·81, those of the bases amount to 21·11: and 15·81 : 21·11 : : 3 : 4 very nearly. Hence one-half of the base must be in the state of a simple silicate, and the other half in that of a disilicate. From the last column it is evident that the bases are not regular multiples of each other. As no disilicate of magnesia is known, we may presume that it is in the state of silicate. The atoms of protoxide of iron are almost half those of magnesia. Therefore neglecting the other constituents, as amounting to only a small fraction of an atom, we may consider the mineral as composed of

2 atoms silicate of magnesia,
1 atom disilicate of iron,

The formula will be $2MgS+\underline{f}^2S$.

Sp. 34. *Anthophyllite.*[*]

Strelite, karstin.

This mineral was first observed at Kongsberg in Norway, in a bed of mica slate, and described by Schumacher. It has been found likewise in Greenland, and is said to occur in granite in Mechlenburg.

Colour between yellowish grey and clove brown, with a kind of false metallic lustre; streak white.

It occurs massive, the mass being composed of crystals or crystalline fibres, often disposed in a radiating form. The crystals may be cleaved parallel to a right rhombic prism, with angles of 125° 30′ and 54° 30′, which therefore may be considered as the primary figure. It cleaves also parallel to the axis of the prism.

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[*] From ανθος, *a flower*, and φυλλον, *a leaf*.

Fracture uneven; lustre pearly, inclining to metallic, particularly on the perfect face of cleavage.

Translucent, sometimes only on the edges; brittle.

Hardness 5 to 5·5; specific gravity from 2·940 to 3·1558.

Before the blowpipe infusible per se. It fuses, though with difficulty, along with borax, and yields a glass coloured by iron.

We have three analyses of this mineral, one by Vopelius, one by Leopold Gmelin, and one by me. The results of which are as follow:

Silica,	56·74	56	57·12
Protoxide of iron,	13·94	13	13·52
Magnesia,	24·35	23	25·92
Protoxide of manganese,	23·8	4	—
Lime,	—	2	1·32
Alumina,	—	3	trace
Water,	1·67	—	1·36
	99·08*	101†	99·24‡

The first three of the constituents are identical in the three analyses. As the others vary, the probability is, that they are not essential to the constitution of the mineral.

In Vopelius's analysis, the bases are rather less than half the atoms of silica, but in Gmelin's they are rather more, and in mine almost exactly half. The mean of the three gives us very nearly the atoms of silica to those of the bases, as 2 to 1. Hence it is evident, that the mineral is composed of bisilicates. The atoms of oxide of iron are to those of magnesia very nearly as 1 to 3. We may therefore consider anthophyllite as composed of

3 atoms bisilicate of magnesia,
1 atom bisilicate of iron.

Sp. 35. *Mellilite.*§

This mineral was discovered by M. Fleuriau de Bellevue, at Capo del Bove, in the environs of Rome.

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[*] Vopelius; Poggendorf's Annalen, xxiii. 355. [†] Gmelin, ibid. p. 358.

[‡] Constituents of a specimen in my cabinet analyzed by me. The specimen was I believe from America, and very characteristic.

[§] Hauy's Mineralogie, iv. 504. Mohs' Mineralogy, iii. 125. The name of the mineral is derived from *mel*, *honey*, on account of its colour.

Colour honey yellow.

It occurs in small square prisms having their edges mostly replaced by tangent planes. The crystals are so small that their shape can only be seen distinctly by means of a microscope.

According to Fleuriau, it is hard enough to strike fire with steel. Opaque.

Before the blowpipe it melts with effervescence into a transparent glass.

Its powder when put into nitric acid is converted into a fine transparent jelly.

Its constituents, as determined by Carpi, are

		Atoms.
Silica,	38·0	19
Lime,	19·6	5·6
Magnesia,	19·4	7·76
Alumina,	2·9	1·28
Oxide of iron,	12·1	2·42
Titanic acid,	4·0	0·76
Oxide of manganese,	2·0	0·44
	98·0	

The atoms of silica and titanic acid amount together to 19·76; while those of the bases are 17·5. It is clear from this, that a portion of these bases must be in the state of a bisalt, or combined with two atoms of acid. If we leave out the titaniate as foreign, the constitution of the mineral is probably

3 atoms silicate of magnesia,
2 atoms silicate of lime,
1 atom bisilicate of iron,

The formula will be $3MgS+2CalS+\underline{f}S^2$.

Sp. 36. *Mountain Cork.*

This mineral occurs occasionally in primary rocks. Though it bears some resemblance to mountain leather, yet its constitution is quite different.

Colour light buff; composed of very fine fibres, only to be distinguished by means of a microscope.

Soft enough to be indented by the nail.

Lustre silky; nearly dull; opaque; tough; specific gravity 2·442.

Before the blowpipe fuses into a black glass. When heated to redness it loses 1·2 per cent. of its weight, and becomes dark nut brown. Its constituents after ignition, are

		Atoms.
Silica,	51·75	25·87
Lime,	14·05	4·61
Magnesia,	10·85	4·34
Protoxide of iron,	18·90	4·20
Protoxide of manganese,	1·85	0·41
Alumina,	1·95	0·86
	99·35	

If we leave out the alumina, the atoms of silica are twice the atoms of the bases. It is evident from this that the mineral consists of bisilicates, and they approach

1 atom bisilicate of lime,
1 atom bisilicate of magnesia,
1 atom bisilicate of iron,

The formula is obviously $\mathrm{CalS}^2+\mathrm{MgS}^2+\underline{f}\mathrm{S}^2$.

It therefore approaches pyroxene in its constitution; and will be reckoned a pyroxene by those chemists who embrace the doctrine of isomorphism.

Sp. 37. *Hydrous Anthophyllite.*

I received the mineral which was distinguished by this name from Dr. Torrey of New York. Its locality was the neighbourhood of New York.

Colour greenish yellow.

Texture diverging fibrous. The whole specimen consisted of a series of plates or very imperfect crystals diverging from various centres, or it was what Werner denominated scopiform. The fibres could be separated from each other, but much more imperfectly than those of asbestus. They were fine, but easily broken, and utterly destitute of elasticity.

Lustre silky; opaque; sectile; feel soft.

Hardness 2·5; specific gravity 2·911.

Its constituents, according to my analysis, are

		Atoms.	
Silica,	54·980	27·49	39·69
Magnesia,	13·376	5·35	7·75
Peroxide of iron,	9·832	1·97	3·85
Protoxide of manganese,	1·200	0·26	0·38
Potash,	6·804	1·13	1·63
Alumina,	1·560	0·69	1
Water,	11·448	10·17	14·73
	99·200		

If we consider the alumina and protoxide of manganese as accidental ingredients, the constituents are in the state of tersilicates, and nearly in the following proportions:

4 atoms tersilicate of magnesia,
2 atoms tersilicate of iron,
1 atom tersilicate of potash,
7½ atoms water.

The formula is $4MgS^3+\underline{f}S^3+KS^3+7\frac{1}{2}Aq$.

The three following minerals do not belong to the tribe of zeolites, but they are placed here on account of the water which they contain.

GENUS IX.—ALUMINUM.

It is scarcely necessary to observe, that hitherto aluminum has not been met with in the mineral kingdom, but only its oxide *alumina*, which possesses the properties of a base or alkaline substance. It is a much more abundant constituent of the earth in this state than any of the other bases; for there are few rocks into which it does not enter as an ingredient.

The number of mineral species into which alumina enters as the most abundant base, amount to about 138. In consequence of this great number of species, it will be of importance to subdivide the genus, and an obvious chemical division suggests itself, founded on the relative simplicity of the constitution of the aluminous minerals. This subdivision is as follows:

Section 1. Alumina pure or combined with a base.
2. Simple salts of alumina.
3. Double anhydrous aluminous salts.
4. Double hydrous salts soluble in water.
5. Double hydrous aluminous sulphates and phosphates insoluble in water.
6. Double hydrous aluminous silicates, or zeolites.
7. Triple aluminous salts.
8. Quadruple aluminous salts.

We shall describe the mineral species belonging to each of these sections in succession.

Section 1. *Alumina pure or combined with a base.*

This section contains 6 species of aluminous minerals; namely,

1 Sapphire,
2 Spinell,
3 Automalite or Gahnite,
4 Sapphirine,
5 Candite,
6 Dysluite.

The first of these when pure is composed of alumina in a crystallized state. In the other six the alumina acts the part of an acid, being combined with a base. In spinell the base is magnesia, in automalite it is oxide of zinc. In ceylanite (a subspecies of spinell), it is magnesia and oxide of iron. In sapphirine and candite it is magnesia and oxide of iron, and in dysluite it is oxide of zinc, oxide of iron, and oxide of manganese. It is curious, that the crystalline form of all the minerals in which alumina acts the part of an acid, so far as it has been observed, is the regular octahedron.

Sp. 1. *Sapphire.**

Oriental amethyst, corundum, diamond spar, emery, telesia, oriental topaz, salamstein, asteria of Pliny.

There are two varieties of this mineral, which were long considered as constituting distinct species; namely, *sapphire* and *corundum*. The *sapphire* constitutes the precious stone, formerly distinguished by the names of *oriental ruby*, *sapphire*, and *topaz*. The *corundum* is commonly grey, or brown, or red, and being opaque and destitute of beauty, cannot be employed as a precious stone; though in other respects it agrees with the first variety. It was at last discovered, that the chemical composition and crystalline form of the two are identical. This induced mineralogists to class them under one species.

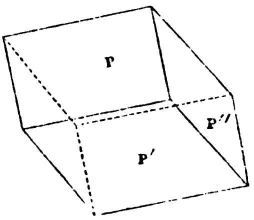
The colour of sapphire varies considerably. When *red*, it is called by jewellers *ruby*; when *blue*, *sapphire*; when *yellow*, *topaz*; when *green*, *emerald*; and when *violet*, *amethyst*.

It is harder than any other mineral except the diamond, and in the table of hardness, that of sapphire is denoted by 9.

It occurs crystallized, and the primary form is an acute rhomboid.

P on P′ 86° 4′

The lateral edges of this rhomboid are frequently replaced by planes parallel to the perpendicular axis of the rhomboid. When these new faces increase so much in size as to obliterate



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* Theophrastus employs the word *σαπφειρος*, and Pliny describes the *sapphirus*; but it is obvious from his description that the name was applied to a very different stone; seemingly the *lapis lazuli*.

the primary faces, a regular six-sided prism is produced, which is the common form of the corundum. Not unfrequently the terminal solid angles of the rhomboid are replaced by six planes. These often increase so as to obliterate the primary faces, in which case a dodecahedron is produced, consisting of two six-sided pyramids applied base to base. These pyramids differ in their lengths and in their angles.

Structure foliated, but this is more evident in the corundum than in sapphire.

Fracture conchoidal, uneven.

Lustre vitreous; transparent to opaque.

Refracts doubly.

Specific gravity 3·9511.

The first good analysis of this mineral was by Klaproth in 1795. He states its constituents to be

Alumina, . . .	98·5
Oxide of iron, . .	1·0
Lime, ...	0·5
	100·0*

But the alumina actually found by him was only 95·08. For he converted it into alum crystals, which weighed 85·6, and of course contained 95·08 alumina. There was therefore a loss in his analysis of 3·42 per cent.

Chenevix† analyzed both the precious stone and corundum in 1802. The following table shows the results of his investigations.

	Blue Sapphire.	Red Sapphire.	Corundum from					
			Carnatic.	Malabar.	China.	Ava.	China.	Bengal.
Alumina, . .	92	90	91	86·5	86·9	87	89·5	84
Silica, . . .	5·25	7	5	7	5·25	6·5	5·5	6·5
Oxide of iron, . .	1	1·2	1·5	4	6·5	4·5	1·25	7·5
	98·25	98·2	97·5	97·5	98·65	98	96·25	98

But there is reason to suspect, that the silica found by Chenevix was at least chiefly abraded from the agate mortar, in which the mineral was pounded. For Dr. Thomas Muir, at my request, analyzed a very fine white crystal of this species having the form of a six-sided prism, and found it composed of pure alumina. For the silica found was only 1·54 per cent., which was just the quantity that had been abraded from the mortar. From this analysis we are entitled to conclude, that pure colourless sapphire is composed of alumina and nothing else.

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* Beitrage, i. 81.

† Phil. Trans. 1802, p. 327.

The sapphire has been occasionally found in the sand of rivers. The finest specimens came from Pegu, where they occur in the Capelan mountains near Syrian. It has been found also at Hohenstein in Saxony, at Biblin in Bohemia, and at Puy in France. The corundum occurs in imbedded crystals in a rock which consists, according to Count Bournon, of Indianite, and contains felspar, fibrolite, several varieties of augite, and also octahedral iron ore. The hair brown or reddish brown varieties, are called *adamantine spar*. They occur with fibrolite and octahedral iron ore in a sort of granite containing no quartz.

The substance called *emery*, which is brought to this country from the island Naxos in the Archipelago, is considered from its composition and hardness, to be a variety of this species.

Its colour is grey; its lustre shining and adamantine; its fracture small grained uneven, or sometimes splintery. It is opaque, and so hard that it scarcely yields to the file. Specific gravity about 4. Reduced to a fine powder it is much used for polishing hard bodies. Its constituents, according to the analysis of Mr. Smithson Tennant, are

Alumina, . . .	86
Silica, . . .	3
Oxide of iron, . .	4
	93*

Sp. 2. *Spinell.*

Balass ruby, spinell ruby, ceylanite, pleonast, rubicelle, almandine ruby.

This mineral had been long employed by the jewellers; but it was first distinguished as a peculiar species by Romé de Lisle.

Its colour is most commonly *red;* but it is found also *blue*, and not unfrequently of a fine *green*. It occurs also yellow, brown and black. Sometimes nearly white.

Its crystals are regular octahedrons. Sometimes the edges are replaced by tangent planes. It occurs also in dodecahedrons with rhomboidal faces, the figure which it assumes when the planes replacing the edges become so large as to obliterate the primary faces of the crystals. Sometimes the octahedral and dodecahedral faces occur together, while at the same time each solid angle of the primary octahedron is replaced by four planes.

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* Phil. Trans. 1802, p. 400.

Fracture conchoidal; lustre vitreous, sometimes splendent, sometimes dull; varies from transparent to opaque.

Hardness 8; specific gravity of the red transparent variety 3·523; of the black opaque variety, called ceylanite, 3·575.

Before the blowpipe per se undergoes no alteration. With borax fuses slowly into a transparent glass with little colour. Fuses also with difficulty in biphosphate of soda. Does not fuse, but swells up with carbonate of soda.

The following table exhibits the constituents of this mineral according to the most modern and best analyses hitherto made:—

	[*]	[†]	[‡]	[§]	[‖]
Silica, . . .	—	5·48	5·620	5·596	2
Alumina, . .	82·47	72·25	73·308	61·788	68
Magnesia, . .	8·78	14·63	13·632	17·868	12
Protoxide of iron, .	—	4·26	7·420	10·564	16
Lime, . . .	—	—	trace	2·804	—
Chromic acid, . .	6·18	1·83[¶]	—	—	—
Water, . . .	—	—	—	0·980	—
	97·83	98·45	99·980	99·6	98

The specimen of spinell which I analyzed was in pure transparent crystals of a fine green colour. Its atomic constituents are,

		Atoms.
Silica, . .	2·81	. 0·51
Alumina, . .	32·13	. 5·9
Magnesia, . .	5·45	. 1
Protoxide of iron,	1·65	. 0·3

It is probable that the protoxide of iron is in combination with the silica, and only an accidental constituent, as it is not always present. If the magnesia and alumina be the essential constituents, as is probable, then spinell is a compound of

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[*] Red transparent spinell. Vauquelin, Jour. des Mines, vii. 1.

[†] Berzelius.

[‡] A dark green variety from the United States. By my analysis.

[§] Black spinell or ceylanite from the United States. By my analysis.

[‖] Ceylanite analyzed by Collet Descotils. Ann. de Chim. xxxiii. 11.

[¶] Undetermined matter.

6 atoms alumina,
1 atom magnesia.

It was shown long ago by Chenevix, that alumina and magnesia have a strong affinity for each other. If we throw down a mixture of alumina and magnesia dissolved in muriatic acid by caustic ammonia, the precipitate after being washed and dried will be found to contain both alumina and magnesia. If we digest it in muriatic acid after ignition, there will remain a white insoluble powder composed of six atoms alumina and one atom of magnesia, and consequently analogous to spinell.

The atomic proportions of ceylanite, deduced from my analysis, are as follow:—

		Atoms.
Silica, . .	2·79 .	0·6
Alumina, . .	27·45 .	6
Magnesia, . .	7·15 .	1·56
Protoxide of iron,	2·34 .	0·51

The silica and protoxide of iron seem to be united atom to atom. But the atoms of alumina are to those of magnesia as 4 to 1. It seems clear from this, that ceylanite constitutes a species different from spinell. If the magnesia and alumina are the only essential constituents, then it is a compound of

4 atoms alumina,
1 atom magnesia.

If the silicate of iron be also essential, then it is

2 atoms quater aluminate of magnesia,
1 atom silicate of iron.

And the formula will be $2MgAl^4+\underset{\cdot}{f}S$.

The finest crystals of spinell come from Ceylon, where they occur in alluvial deposites. In Sweden spinell is scattered through a primitive limestone. It is similarly situated in North America.

It must not be concealed that the analyses of spinell and ceylanite, lately published by Hermann Abich,* differ considerably in their result from those on which I have founded my opinion respecting the constitution of this mineral. The spinell was found by him composed of

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* Poggendorf's Annalen, xxiii. 305.

	*	†
Silica,	2·25	2·02
Alumina,	68·94	69·01
Magnesia,	25·72	26·21
Protoxide of iron,	3·49	0·71
Protoxide of manganese,	trace	—
Oxide of chromium,	—	1·10
	100·40	99·05

He ascribes the different results of preceding chemists to their not having taken into account the silica abraded from the agate mortar during the process of pulverizing. It is obvious at a glance that the quantity of magnesia relatively to the alumina is doubled. For the atomic constituents of red spinell are

		Atoms.
Silica,	1·01	0·09
Alumina,	30·67	2·92
Magnesia,	10·5	1
Protoxide of iron,	0·15	0·01
Oxide of chromium,	0·55	0·05

If we neglect the other constituents as insignificant and inconstant, the composition of red spinell will be

3 atoms alumina,
1 atom magnesia.

We have four analyses of ceylanite by the same chemist, made apparently with every attention to accuracy. The results of these analyses will be seen in the following table:—

	‡	§	‖	¶
Silica,	2·50	1·23	2·38	1·79
Alumina,	65·27	68·79	67·46	59·66
Magnesia,	17·58	23·61	25·94	17·70
Protoxide of iron,	13·97	8·07	5·06	19·29
Oxide of chromium,	—	—	—	0·73
Protoxide of manganese,	—	—	—	trace
	99·32	102·80	100·84	99·17

From the great variation in the quantity of protoxide of

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* Blue spinell from Aker, in Sweden.

† Red transparent spinell, from Ceylon.

‡ Ceylanite from the Ural.

§ Ceylanite from Monzoni.

‖ Ceylanite from Vesuvius.

¶ Ceylanite from Iserweise.

iron, we can hardly consider it as an essential constituent; though undoubtedly the mineral is indebted to it for its black colour. The atomic constituents of the third variety, which is the freest from iron, are as follow:—

	Atoms.
Silica, . . .	1·19
Alumina, . .	30
Magnesia, . .	10·37
Protoxide of iron, .	1·12

It is obvious at a glance that it consists of

3 atoms alumina,
1 atom magnesia,

and is therefore, according to Abich's investigations, chemically the same as spinell.

Sp. 3. *Automolite,*[*] *or Gahnite.*

This mineral was discovered in 1805, by Assessor Gahn, in Eric Matt's mine, near Fahlun, where it is interspersed in small crystals in a talc slate. Its constitution was ascertained in 1806, by Ekeberg.[†]

The colour is a dark dirty green; streak white.

It is always crystallized either in regular octahedrons, or in the *octoedne transposé* of Hauy. So that it has the same crystalline shape as the spinell.

Cleaves parallel to the faces of the regular octohedron.

Cross fracture conchoidal; opaque, or only translucent on the edges.

Hardness 7·25; but very easily frangible.

Specific gravity, as determined by Ekeberg, 4·261. When heavier it contains, interspersed, galena; when lighter it is not free from a mixture of talc.

Infusible per se before the blowpipe. With borax it fuses with difficulty into a clear glass, greenish while hot, but colourless when cold. With biphosphate of soda it fuses into a clear glass bead. With carbonate of soda it does not enter into fusion.

Besides the original analysis of this mineral by Ekeberg, we have an analysis of it by Vauquelin, and two by Abich.

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[*] From αυτομολος, a deserter. Named on account of the presence of oxide of zinc in a mineral not resembling an ore.

[†] Afhandlingar, i. 84.

The following table exhibits the result of these researches:

	*	†	‡	§
Silica, ...	4·75	4	3·84	1·22
Alumina, ...	60	42	55·14	57·09
Magnesia, ...	—	—	5·25	2·22
Oxide of zinc, . . .	24·25	28	30·02	34·80
Protoxide of iron, .	9·25	5	5·85	4·55
Sulphur, ...	—	17	—	—
Undecomposed, . . .	—	1	—	—
	98·25	97	100·10	99·88

In these analyses, the silica, magnesia, and even oxide of iron, differ so much from each other that we can hardly consider them as essential ingredients. Ekeberg's analysis gives us the atomic ratio of the alumina to the oxide of zinc as 6 to 1. But Abich's, which, from the care with which they were made, seem entitled to confidence, give us the atoms of alumina to those of oxide of zinc as 4 to 1.

It is probable, therefore, that in Gahnite, the essential constituents are

4 atoms alumina,
1 atom oxide of zinc.

Sp. 4. *Sapphirine.*

This mineral was discovered by Sir Charles Giesecke, in Greenland, at Fiskenaes or Kikertarsoeitsiak. He sent specimens of it to Stromeyer, who described its characters, and ascertained its composition.

It has a pale sapphire blue colour.

The specimen in my possession (for which I was indebted to the kind liberality of Sir Charles Giesecke), consists of foliated grains interspersed through mica slate, without any distinct crystalline shape.

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* Ekeberg, Afhandlingar, i. 84.

† Vauquelin, Gehlen's Jour. (second series), ii. 38.

‡ Abich. Poggendorf's Annalen, xxiii. 332. The specimen analyzed was from Fahlun.

§ Abich, ibid. The specimen was from the United States. It occurs in a rock composed of quartz, hornblende, calcareous spar, and albite. Abich found a trace of manganese and of cadmium in the American specimen.

Lustre vitreous and splendent.

Translucent, at least on the edges.

Hardness 7·75; specific gravity, as determined by Stromeyer, 3·4282.

Before the blowpipe quite infusible, even when heated with borax. Not altered by exposure to a strong red heat.

Its constituents, as determined by the analysis of Stromeyer,* are as follow:

		Atoms.	
Silica,	14·507	7·25	3·22
Alumina,	63·106	28·04	12·49
Magnesia,	16·848	6·74	3
Lime,	0·379	0·10	0·04
Protoxide of iron,	3·924	0·87	0·38
Protoxide of mangan.,	0·528	0·12	0·05
Loss by ignition,	0·492		
	99·784		

If the alumina and magnesia were to be considered as the only essential constituents of this mineral, it would be a compound of

4 atoms alumina,
1 atom magnesia.

If the silica be deemed essential, the mineral might be considered as composed of

2 atoms sexaluminate of magnesia,
1 atom tersilicate of magnesia.

Sp. 5. *Candite.*

This is a very hard black massive mineral from Candy, in Ceylon, for the analysis and description of which we are indebted to Dr. C. G. Gmelin, of Tubingen.†

The colour is velvet black. It is massive, has a conchoidal fracture, a glassy lustre, and a hardness equal to that of spinell.

Its specific gravity is 3·617.

It is infusible without addition by the blowpipe. With biphosphate of soda it fuses readily into a translucent green glass. With borax it melts and forms a greenish glass. With carbonate of soda it swells up, but does not melt.

Its constituents, as determined by Gmelin, are

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* Untersuchungen, p. 391.

† Edinburgh Phil. Jour. ix. 384.

		Atoms.	
Alumina,	57·200	25·42	27·84
Protoxide of iron,	20·524	4·56	5
Magnesia,	18·240	7·30	8
Silica,	3·154	1·52	1·66
	99·118		

If we admit the silica to be combined with alumina in the state of silicate of alumina, and to be accidentally present, which is the opinion entertained by Gmelin, then candite is composed of

5 atoms binaluminate of iron,
8 atoms binaluminate of magnesia,

and its formula will be $8\mathrm{MAl}^2+5\underline{f}\mathrm{Al}^2$.

Sp. 6. *Dysluite.*

This mineral occurs at Sterling, New Jersey, in a dark-coloured limestone, along with octahedral iron ore, and various other minerals. It seems to have been discovered and named about ten years ago, by Mr. Keating. But so far as I have had an opportunity of knowing, no description or analysis of it has been hitherto published. The name *dysluite* was imposed, I presume, in consequence of the difficulty of decomposing this mineral by fusing it with carbonate of soda.

It is scattered through the limestone in small crystals, which have the form of regular octahedrons.

The colour is yellowish brown; and the shade varies somewhat in intensity in different crystals.

Texture foliated; opaque.

Hardness 4·5; specific gravity 4·551.

Lustre splendent and vitreous when the faces of the crystals are smooth, which is generally, but not always the case; easily frangible.

Before the blowpipe it assumes a red colour, which it loses on cooling, and the assay remains unaltered in its appearance. When heated on charcoal it becomes darker coloured, but does not melt. With carbonate of soda it does not fuse; but the soda, while in fusion, has a fine red colour, which it loses on cooling. With biphosphate of soda no fusion. While the biphosphate is in a melted state it has a fine red colour, which changes to a yellow on becoming solid, and when cold the salt resumes its white colour and transparency, the assay remaining unaltered in the centre. In borax it dissolves very slowly.

The bead is transparent, and has a very deep garnet red colour.

The constituents of this mineral, determined by my analysis of it, are as follow:

		Atoms.
Alumina, . .	30·490 .	13·55
Oxide of zinc, .	16·800 .	3·2
Peroxide of iron,	41·934 .	8·38
Protoxide of manganese,	7·600 .	1·69
Silica, . .	2·966	
Moisture, . .	0·400	
	100·22	

The silica was probably accidental, for in some cases I found hardly any traces of it in the mineral. The constituents are obviously

5 atoms aluminate of iron,
2 atoms aluminate of zinc,
1 atom aluminate of manganese.

The constitution of this mineral is not a little remarkable. The alumina, as in all the other species belonging to this section, acts the part of an acid, but it is the only example of a congeries of simple aluminates which has hitherto been met with in the mineral kingdom.

Sect. 2. *Simple Salts of Alumina.*

The minerals belonging to this section amount to 24 species. In them the alumina is united simply to an acid, or to some substance which acts the part of an acid. These acid substances are water, mellitic acid, sulphuric acid, fluoric acid, phosphoric acid, and silicic acid. No fewer than 15 of the 24 species are silicates.

Sp. 1. *Gibbsite,** *or Hydrate of Alumina.*

This mineral was discovered by Dr. Emmons, in an iron mine at Richmond, Massachusetts. Its nature was first determined by Dr. Torrey.†

It occurs in irregular stalactites and tuberose masses.

Structure fibrous, fibres radiating from the centre; lustre vitreous, nearly dull.

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* Named from Colonel Gibbs.

† New York Medical and Physical Journal, No. i. p. 68.

Colour white, with a slight shade of green or grey; slightly translucent.

Hardness 2·75; specific gravity, by my trials, 2·091. Dr. Torrey states it to be 2·400.

Before the blowpipe whitens and gives out water, but is infusible.

I found its constituents to be

		Atoms.	
Silica,	8·73	4·36	4·39
Alumina,	54·91	24·40	24·51
Peroxide of iron,	3·93	0·78	0·78
Water,	33·60	29·86	30
	101·17		

It is obvious that the atoms of water very nearly correspond with those of the other constituents. Hence it consists of a congeries of hydrates. We may consider the constitution of the mineral as

25 atoms hydrate of alumina,
5 atoms hydrate of silica,
1 atom hydrate of iron.

Probably it exists in a purer state than in the specimen analyzed by me. Dr. Torrey obtained

		Atoms.
Alumina,	64·8	28·8
Water,	36·7	30·8
	99·5	

This approaches

1 atom alumina,
1 atom water.

There is a mineral which exists in considerable quantity on the hill of Beaux, near Arles, which approaches gibbsite very closely in its chemical composition, though it differs in its external characters. It consists of round or amorphous pieces about the size of a pea, agglutinated in a paste of the same nature. The colour is blood red, and the fracture compact and shining. The specific gravity is inconsiderable, though it varies a good deal in different specimens. The constituents, as determined by the analysis of Berthier, are

		Atoms.	
Alumina,	52·0	23·11	5
Water,	20·4	18·13	3·92
Peroxide of iron,	27·6		
Oxide of chromium,	trace		
	100·0*		

Berthier has shown that the peroxide of iron is only mechanically mixed with the hydrated alumina. It is obvious that the alumina and water are nearly in the proportion of

$1\frac{1}{4}$ atom alumina,
1 atom water.

The probability is that the mineral was originally a simple hydrate of alumina, but that it had lost a portion of its water before it was analyzed.

Sp. 2. *Bihydrate of Alumina.*

This mineral was found in 1786, by M. Lelievre, on the sides of the gallery of a lead mine in the mountain of Esqueme, situated on the left bank of the Oo, in the Pyrenées.

It has a white colour, with sometimes a shade of yellow and apple green in the centre; opaque, or only slightly translucent. It has a resinous fracture; its hardness is 3·25. It adheres to the tongue, and when put into water absorbs the sixth of its weight of that liquid.

Before the blowpipe it is infusible per se, and gives out no phosphorescent light. Nitric and sulphuric acid attack it without the assistance of heat, and convert it into a saline magma. Its constituents, according to the analysis of Berthier, are

		Atoms.		
Alumina,	44·5	19·77	2·63	1
Water,	40·5	36	4·8	1·81
Silica,	15·0	7·5	1	0·37
	100·0†			

If we neglect the silica, as probably not chemically combined, the mineral is very nearly a compound of

1 atom alumina,
2 atoms water.

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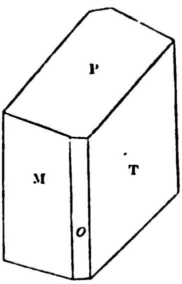
[*] Ann. des Mines, vi. 531.

[†] Ann. de Chim. et de Phys. vi. 333.

Sp. 3. *Diaspore*,[*] *or Dihydrate of Alumina.*

This mineral was accidentally found many years ago, by M. Lelievre, in the hands of a dealer, and nothing whatever was known for many years about its locality. Another piece of it came into the possession of Mr. Sowerby of London, in 1822, and he was of opinion that he would be able to discover the place from which it had come,[†] but I am not aware that any thing farther has been published on the subject. Mr. W. Phillips informs us that a third specimen of it is in the mineral cabinet of Mr. S. L. Kent.[‡] Very lately M. Fiedler has announced that the locality of diaspore is a primary limestone not far from Ekatherinburg, in the Marmorbruch, at the back of the Koroibrod.[§]

Colour greenish grey.



Texture foliated and crystallized. The primary crystal, according to the measurement of Mr. Phillips, is a doubly oblique prism, with the following angles:

M on T 65° 0′
P on M 108° 30′
P on T 101° 20′

The plane *o*, though well defined, is not brilliant enough for measurement. It is probably a tangent plane, in which case M on *o* will be 122° 30′.

Lustre vitreous; translucent on the edges; scratches glass; specific gravity 3·4324, according to Hauy.

Before the blowpipe it decrepitates most violently, and splits into many small scaly particles, having the appearance of boracic acid. Berzelius says that these particles restore the blue colour of reddened litmus paper, but Mr. Children did not find this to be the case in the specimen in the possession of Mr. Sowerby. The constituents of diaspore, according to Vauquelin's analysis, are

Alumina, . .	80
Protoxide of iron, .	3
Water, . . .	17·3
	100·3[‖]

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[*] So called from διασπειρω, I disperse, because it divides into small scaly particles before the blowpipe.

[†] Annals of Philosophy (second series), iii. 433.

[‡] Ibid. iv. 17.

[§] Poggendorf's Annalen, xx. 322.

[‖] Ann. de Chim. xlii. 113.

Mr. Children analyzed another specimen, and states its constituents:

		Atoms.
Alumina,	76·06	33·8
Protoxide of iron,	7·78	1·72
Water,	14·70	13·06
	98·54*	

From the very different proportions of protoxide of iron in the two specimens, it is likely that it is merely an accidental ingredient. Were we to admit the 1·72 atoms of protoxide of iron to be combined with alumina in the ratio of 1 atom oxide to 5 atoms alumina, then the diaspore would consist of

2 atoms alumina,
1 atom water,

or would be a dihydrate. If this supposition be inadmissible, then diaspore must be a compound of

2½ atoms alumina,
1 atom water.

Sp. 4. *Mellate of Alumina*, or *Honeystone*.

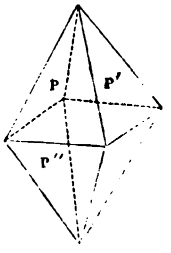
Mellite.

This mineral was discovered a good many years ago, in an earthy brown coal at Artern, in Thuringia, and was first recognised and described as a peculiar species by Werner; but it existed in cabinets, being considered as a variety of amber, at least as early as 1791. Klaproth analyzed it in 1797, and ascertained its nature.

Colour honey yellow, inclining often to red or brown; streak white.

It is always crystallized. Primary form an octahedron, with a square base.

P on P′ 118° 3′
P on P″ 93°



Sometimes all the solid angles of the octahedron are replaced by tangent planes; sometimes the crystal assumes the form of the rhomboidal or garnet dodecahedron.

Hardness 2·75; specific gravity from 1·550 to 1·597.

Before the flame of a candle it whitens, but does not flame. It dissolves in nitric acid, and is decomposed when boiled in water, the alumina being separated nearly pure, and the acid, still retaining a little alumina, being dissolved in the water.

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* Annals of Philosophy (second series), iv. 146.

The constituents, according to the analysis of Klaproth, are

Mellitic acid, .	46
Alumina, . .	16
Water, . .	33
	95[*]

This is probably equivalent to

1 atom mellitic acid, .	6·5
1 atom alumina, . .	2·25
4 atoms water, . .	4·5
	13·25

If this be the constitution, it is a simple hydrous mellate of alumina.

Sp. 5. *Aluminite.*

Hallite, websterite, trisulphate of alumina.

This mineral was observed many years ago in the environs of Hallé, and about the year 1813, it was detected by Mr. Webster in the chalk rocks at New Haven in Sussex.

Colour snow-white. It occurs in reniform pieces of greater or smaller magnitude.

Fracture fine earthy; dull; streak glistening; opaque; adheres feebly to the tongue; soils very slightly; hardness 2; feels fine, but meagre; specific gravity, as determined by Stromeyer, 1·7054.

We are indebted to Stromeyer for an analysis of three varieties of this mineral, and to Lassaigne for a fourth. The following table exhibits the result of these analyses:

	†	‡	§	‖
Sulphuric acid, .	23·370	23·365	23·554	20·06
Alumina, . .	29·868	30·263	30·807	39·70
Water, . . .	46·742	46·372	45·639	39·94
Sulphate of lime,	—	—	—	0·30
	100	100	100	100

It is obvious that the three specimens analyzed by Stromeyer, are identical, and composed of

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[*] Beitrage, iii. 116.

† From New Haven, Sussex. Untersuchungen, p. 99.

‡ From Halle on the Saale. Ibid.

§ From Marle near Halle. Ibid.

‖ From Epernay. Lassaigne, Ann. de Chim. et de Phys. xxiv. 97.

1 atom sulphuric acid,
3 atoms alumina,
9 atoms water.

The specimen analyzed by Lassaigne approaches the others in its composition. Though there is an excess of alumina and rather a deficiency of water. The atomic proportions are,

1 atom sulphuric acid,
3·29 atoms alumina,
8·85 atoms water.

Sp. 6. *Sulphate of Alumina.*

This salt occurs in nests in the transition (alum) slate of the Andes. Specimens of it were sent to this country by Sir Ralph Woodford, late governor of Trinidad, and they were put into my hands by the kindness of Charles Macintosh, Esq. of Crossbasket.

Colour white, except where here and there tinged yellow by external impurities.

It is in fine crystalline scales; lustre silky; translucent; specific gravity 1·6606.

It has the astringent and sweet taste of alum, but is rather stronger. Soluble in water.

Before the blowpipe behaves like alum.

Its constituents, determined by a careful analysis, were found as follows:

		Atoms.
Water,	46·375	41·22
Alumina,	14·645	6·51
Peroxide of iron,	0·500	0·10
Soda,	2·262	0·56
Sulphuric acid,	35·872	7·17
Mechanical impurities (being very ferruginous silica,)	0·100	
	99·754	

The sulphuric acid amounts to 7·17 atoms, and the atoms of alumina, soda, and peroxide of iron, are exactly the same. Hence the mineral consists of simple sulphates with a quantity of water. The constituents are as follow:

1 atom sulphate of alumina,
0·07 atom sulphate of soda,
0·0125 atom sulphated peroxide of iron,
6 atoms water.

The quantity of sulphate of soda and sulphated peroxide of iron is so small that it may be overlooked as an accidental impurity. If so, the salt is composed of

1 atom sulphate of alumina,
6 atoms water.

There is a manufacture of alum at Campsie, near Glasgow. The alum is extracted from the shale of the coal beds in the neighbourhood. At first this shale gave alum when simply lixiviated in water. This process had been continued for a number of years, and a great accumulation of washed shale was made in the neighbourhood of the work. It was found that by burning this washed shale it might be made to yield a new crop of alum. In this burnt shale sulphate of alumina makes its appearance in thin bands.

Its colour is greyish white, interspersed with portions having a yellow colour.

Fracture earthy; opaque; friable; specific gravity 1·887.

Taste acid, astringent, and sweet.

When digested in water it dissolves, with the exception of a white powder amounting to 15·31 per cent., and which is a subsulphate of alumina.

When heated it melts somewhat like alum, and gives out pure water. When heated to redness it swells up like alum, and finally leaves a yellowish white porous tasteless matter, nearly similar to what would be left by alum treated in the same way, only making allowance for the colour.

The constituents of this salt were found by analysis to be as follow:—

Insoluble matter 15·31, composed of

		Atoms.
Alumina,	5·11	2·27
Sulphuric acid,	10·2	2·04
	15·31	

The portion dissolved in water consisted of

		Atoms.
Sulphuric acid,	30·225	6·045
Alumina,	5·372	2·38
Peroxide of iron,	8·530	1·70
Potash,	1·172	0·19
Water,	36·295	32·26
	81·594	
Insoluble matter,	15·310	
	96·904	

There is a loss of 3·096 per cent., which I consider as water. For the whole water cannot be separated from sulphate of alumina, without at the same time driving off a portion of the acid.

The atoms of sulphuric acid are 8·085, while those of the bases are only 6·54. Hence 1·54 atoms of the bases must be in the state bisulphates. The water, if we include the loss, is 35 atoms.

The composition of the salt is very nearly

24 atoms sulphate of alumina,
9 atoms bisulphated peroxide of iron,
1 atom bisulphate of potash,
180 atoms water.

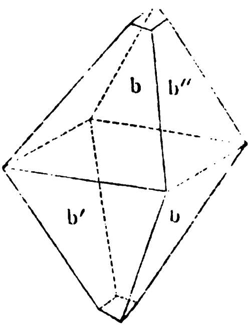
If we leave out the bisulphates, and consider the water as united with the sulphate of alumina, then the constituents of the salt will be

1 atom sulphate of alumina,
7 atoms water.

Sp. 7. *Fluellite*, or *Fluate of Alumina.*

This name was given by Dr. Wollaston to some minute white transparent crystals detected by Mr. Levy on a specimen of Wavellite from Cornwall. The form of the crystal is an acute rhombic octahedron, having its summits replaced by a plane. According to Dr. Wollaston's measurement,

b on b′ 144°
b on b″ 109°
b on b 82°



Hence the primary form may be assumed to be a right rhombic prism the lateral planes of which are inclined to each other at about 105°.

Dr. Wollaston found the index of refraction of fluellite to be 1·47, and that of wavellite 1·52.

He analyzed the mineral on a minute scale, and could detect nothing in it but fluoric acid and alumina. It cannot be a simple fluate of alumina, because that salt is soluble in water. But it may be a difluate of alumina, which Berzelius has shown to be insoluble in water.

Sp. 8. *Tourquois*, or *Trisphosphate of Alumina.*

Calaite, agaphite, johnite, birousa of the Persians.

This mineral has hitherto been found only in Persia, not far from Nichabour, in a mountainous district. Agaphi, the only naturalist who has been on the spot, informs us that the tourquoises occur in thin veins which penetrate the mountain in all directions. We neither know the nature of the mountains nor of the veins in which the tourquoises are found. But they occur either in very thin pieces, or in nodules seldom so large as a nut. They are very much valued by the eastern nations, and the king of Persia is said to reserve all those which have a tolerable size and a good colour for his own use.

Tourquois seems to have been known to the ancients, and is probably the mineral described by Pliny under the name of *calais.*[*] The first tolerably accurate description of it was published by Dr. Fischer of Moscow.[†] Fossil bones coloured by copper had been distinguished by the same name, though they are essentially different.

Colour a peculiar bluish green very pleasant to the eye. It is this colour which gives the mineral its value.

Fracture small conchoidal, sometimes splintery, sometimes uneven.

Lustre dull, or merely glimmering. It admits of a polish, but even then the lustre is inconsiderable. It is vitreous.

Opaque; sometimes, though rarely, translucent on the edges.

Rather softer than quartz; powder white; specific gravity from 2·6296 to 3·25. It is evident from this that various substances are at present confounded under the name of tourquois.

Its constituents, as determined by the analysis of John, are

			Atoms.
Alumina,	44·50	19·77	3
Phosphoric acid,	30·90	6·86	1·04
Oxide of copper,	3·75	0·75	0·11
Protoxide of iron,	1·80	0·40	0·06
Water,	19·00	16·88	2·56
	99·95[‡]		

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[*] Lib. xxxvii. c. 8.

[†] Annals of Philosophy, xiv. 406.

[‡] Ann. des Mines (second series), iii. 231.

If we omit the small quantity of oxides of copper and iron, the mineral is a compound of

1 atom phosphoric acid,
3 atoms alumina,
$2\frac{1}{2}$ atoms water.

It is therefore a hydrous trisphosphate of alumina.

Berzelius informs us that he analyzed tourquois, and found it to consist of phosphate of alumina, phosphate of lime, silica and oxides of iron and copper.* It is probable that the specimen, analyzed by Berzelius, differs essentially from that analyzed by John, as the latter chemist detected neither lime nor silica in his specimen.

Sp. 9. *Andaluzite*,† or *Disilicate of Alumina.*

Micaphyllite, Stanzaite.

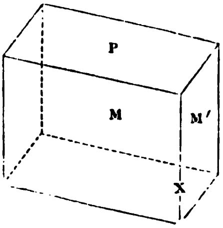
This mineral was first observed by Count Bournon in a primitive granite mountain in Forez, and described by him in the Journal de Physique for 1789. It was afterwards discovered in Andalusia.‡ It occurs near Braunsdorf, in Saxony, and in other parts of Germany. Crystals of large size are found in the valley of Lisenz, near Inspruck, in the Tyrol. It has been observed also in the granite near Aberdeen, and in the granite mountains of Glen Malor, in the County of Wicklow, both in crystals and in amorphous masses.

Colour flesh red, passing into pearl grey, also brownish red; streak white.

In the granite of Wicklow it occurs in large amorphous masses, having a brownish red colour and a granular structure. But it is most commonly crystallized. The primary form is a right rhombic prism in which

M on M′ 91° 20′

The edge X is often replaced by two planes, making with each other an angle of 125°. The acute solid angles are also sometimes replaced by one or two triangular planes, making an angle of 140° with the base of the prism. In large crystals the angle M on M′ is not constant. I measured several from Spain an inch in diameter, and several inches in length. M on M′ varied from 92° to



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* Ann. des Mines, vii. 223.

† Because it was first found in Andalusia.

‡ Hence the name *andalusite*.

94°. But the faces were not quite smooth, nor he edges of the prisms perfect.

Fracture uneven; lustre vitreous; translucent on the edges.

Hardness 4·25; specific gravity of a specimen from the Linzenz Alps in the Tyrol 3·314; of a specimen from the west of Dublin 3·13.

Infusible before the blowpipe, but becomes covered with white spots. Fuses with extreme difficulty with borax and biphosphate of soda.

Its constituents, as determined by analysis, are as follow:—

	*	†	‡	§	‖
Silica, . . .	34·000	36·5	32	35·304	30·92
Alumina, . . .	55·750	60·5	52	60·196	64·60
Potash, . . .	2·000	—	8	—	1·75
Protoxide of iron, .	3·375	4·0	2	1·324	—
Protoxide of manganese,	0·625	—	—	—	0·50
Lime, . . .	2·125	—	—	—	—
Magnesia, . . .	0·375	—	—	1·000	0·96
Water, . . .	1·000	—	6	2·032	0·90
	99·25	100·1	100	99·856	99·63

The atomic constituents deduced from my analysis are,

		Atoms.
Silica, . .	17·65 .	1·31
Alumina, . .	26·75 .	2
Protoxide of iron,	0·29 .	0·02
Magnesia, . .	0·40 .	0·03

If we consider the protoxide of iron and the magnesia as silicates, and as accidental ingredients, we see that andaluzite approaches pretty nearly to a compound of

1 atom silica,
2 atoms alumina.

It is therefore a disilicate of alumina.

Sp. 10. *Hydrous Trisilicate of Alumina.*

This mineral was discovered in 1786 by M. Lelievre while

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[*] Brandes, Schweigger's Jour. xxv. 113. The specimen was from the Tyrol.

[†] Bucholz, as quoted by Haidinger, Mohs' Mineralogy, ii. 295.

[‡] Vauquelin, Brogniart's Mineralogie, i. 36.

[§] By my analysis. The specimen was from the Tyrol, and in crystals.

[‖] From west of Dublin, not crystallized. By the analysis of Dr. Coverdale.

visiting a lead mine on the mountain Esquerre, in the French Pyrenees. Some years later, (or in 1794,) a substance of the same nature was discovered in the shaft of Stephanus at Schemnitz, in Hungary, the nature of which was determined by Klaproth in 1795. Berthier analyzed the specimens brought by Lelievre from Esquerre in 1810, and found the composition identical with that of the mineral from Schemnitz.

Colour snow-white; it is light; very friable; hardly stains the fingers, but adheres to the tongue; opaque.

The centre has sometimes an apple green colour. It is then translucent, has a resinous lustre, and a hardness of 3·25. When put into water it absorbs the sixth part of its weight of that liquid. When ignited in a crucible it cracks, becomes very friable, and loses rather more than 40 per cent. of its weight.

Before the blowpipe it does not melt, nor emit a phosphorescent light, nor give out a white dust as calamine does. It is attacked even cold by nitric and sulphuric acid, which convert it into a saline magma without crystals.

The following table exhibits the composition of this mineral according to the analyses of Klaproth and Berthier:—

	*	†
Silica,	14	15
Alumina,	45	44·5
Water,	42	40·5
	101	100

The atomic proportions, deduced from Klaproth's analysis, are,

		Atoms.
Silica,	7	1
Alumina,	20	2·86
Water,	37·33	5·33

This approaches pretty nearly

1 atom silica,
3 atoms alumina,
5 atoms water.

It is therefore a hydrous trisilicate of alumina.

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* Klaproth, Beitrage, i. 257.

† Berthier Ann. des Mines, ii. 476.

Sp. 11. *Scarbroite.*[*]

Hydrous pentesilicate of alumina.

This mineral was first noticed by the Rev. W. H. Vernon. It occurs in a calcareous rock on the coast of Scarborough, between double laminæ of oxide of iron.

Colour pure white; no lustre.

Massive; fracture conchoidal.

Highly adhesive to most surfaces, and polished by the nail.

When breathed upon it emits a strong earthy smell.

When immersed in water neither becomes transparent nor falls to pieces, but gains considerably in weight.

Specific gravity 1·48; easily scratched with a knife.

Its constituents, as determined by the analysis of Mr. Vernon, are as follow:—

		Atoms.
Silica, . .	7·90	. 3·95
Alumina, . .	42·75	. 19
Water, . .	48·55	. 43·15
Peroxide of iron,	0·80	
	100·00	

This approaches pretty nearly
1 atom silica,
5 atoms alumina,
11 atoms water.

It is therefore a hydrous penesilicate of alumina. Its formula will be $Al^5S+11Aq$.

Sp. 12. *Bucholzite,*[†] or *Anhydrous Silicate of Alumina.*

The first account of this mineral appeared in the twenty-fifth volume of Schweigger's Journal, for the year 1819, written by Dr. Brandes. He had obtained the specimen which he examined from Professor Weiss, and its locality was the Tyrolese Alps. Brandes analyzed it, and published a very imperfect description of it. About the year 1824, I found specimens of it in a collection of American minerals which Mr. Nutall was so obliging as to send me for analysis. The locality was Chester, on the Delaware, south-west from Philadelphia. In 1826, I got larger and better characterized specimens from the same gentleman, which put it in my power to subject it to analysis, and to draw up a description of it.

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[*] Philosophical Magazine (second series), v. 178.

[†] In honour of Bucholz, a celebrated German chemist.

Colour greyish white, with a very slight tinge of yellow, not recognisable in every specimen.

Structure fibrous. The fibres are sometimes bent, and when viewed through a microscope, assume the appearance of plates, or imperfect prismatic crystals.

Lustre silky.

Hardness 6; specific gravity 3·193.

I found its constituents,

		Atoms.
Silica, . .	46·40 .	23·2
Alumina, . .	52·92 .	23·52
	99·32	

It is therefore a simple anhydrous silicate of alumina.

The constituents obtained by Brandes are the following:

Silica, . . .	46
Alumina, . .	50
Protoxide of iron,	2·5
Potash, . .	1·5
	100

The American mineral contained no sensible quantity of iron. I did not search for potash. Should any exist, the quantity cannot exceed two-thirds of a per cent., and of course cannot affect the constitution of the mineral.

Sp. 13. *Gilbertite.*[*]

The mineral to which I have given this name was very abundant about thirty years ago in the lode of Stonagwyn, near St. Austle, Cornwall, when it was known by the name of *talc*. I place it here, though scarcely entitled to the name of a simple aluminous salt, on account of its very close connexion with bucholzite.

The mass of gilbertite in the specimens in my possession, is mixed with dark purple fluor spar, and with specks of another mineral, which has the aspect of apatite.

Colour white, with a slight shade of yellow.

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[*] Named from Davies Gilbert, Esq., late president of the Royal Society.

Composed of plates lying irregularly on each other. It has occasionally a certain approximation to a crystalline form; but the exact shape cannot be determined.

Lustre silky; translucent; sectile.

Easily cut with a knife; hardness 2·75.

Specific gravity 2·648.

Its constituents, as determined by the analysis of Captain Lehunt, in my laboratory, are as follow:

		Atoms.	
Silica,	45·155	22·57	8·86
Alumina,	40·110	17·82	7
Lime,	4·170	1·19	0·47
Magnesia,	1·900	0·76	0·3
Protoxide of iron,	2·430	0·54	0·21
Water,	4·250	3·77	1·48
	98·015		

If we allow that the lime, magnesia, and protoxide of iron are in the state of bisilicates, then gilbertite will be a compound of

7 atoms silicate of alumina,
1 atom bisilicate of lime, magnesia, and iron,
1½ atom water.

And the formula will be

$$7\mathrm{AlS}+(\tfrac{4\cdot75}{10}\mathrm{Cal}+\tfrac{3}{10}\mathrm{Mg}+\tfrac{2\cdot25}{10}f)S^2+1\tfrac{1}{2}\mathrm{Aq}.$$

The difference between the properties of this mineral and bucholzite is doubtless owing to the presence of this triple bisilicate and the water.

Some years ago I got from Mr. Peneluna, a mineral dealer in Helston, a specimen of a Cornish mineral (locality unknown), which is intimately connected with gilbertite, if it be any thing else than a variety of that mineral.

Colour snow-white.

Structure foliated, composed of small plates diverging from a centre.

Lustre pearly, splendent; slightly translucent on the edges.

Hardness 2·25; specific gravity 2·801.

Before the blowpipe does not fuse, but it assumes a vitreous lustre. With carbonate of soda fuses into an opaque bead, yellow while hot, but becoming white on cooling. With borax fuses slowly into a translucent glass, leaving silica floating through it. With biphosphate of soda the same, but the fusion is very imperfect. Its constituents, on analysis, proved to be

		Atoms.	
Silica,	47·796	23·89	21·43
Alumina,	32·616	14·49	13·00
Magnesia,	1·600	0·64	0·57
Protoxide of iron,	5·176	1·15	1·03
Soda,	9·232	2·31	2·07
Water,	4·000	3·55	3·11
	100·420		

This is equivalent to

13 atoms silicate of alumina,
2 atoms bisilicate of soda,
1 atom tersilicate of iron,
½ atom bisilicate of magnesia,
3 atoms water.

The formula will be

$$26AlS+4NS^2+2\underline{f}S^3+MgS^2+6Aq.$$

We see that the greater part of the mineral (as is the case with gilbertite), is silicate of alumina. The other salts differ from those in gilbertite. Is it not probable that gilbertite in a state of purity, would be merely a hydrous silicate of alumina?

Sp. 14. *Hydrous Bucholzite.*

I give this name to a mineral which I found in possession of Charles M'Intosh, Esq., of Crossbasket. Unfortunately we are quite ignorant of the locality, except that it was brought from the island of Sardinia.

Colour light bluish green; streak white; powder white.

Structure granular, being composed of small scales; brittle.

Lustre vitreous; translucent.

Hardness 3; specific gravity 2·855.

Before the blowpipe becomes snow-white, and falls into powder, from the loss of water.

With carbonate of soda effervesces, and forms slowly an opaque white frit; or an enamel, if the quantity of soda be more considerable. With borax it fuses immediately into a transparent bead, leaving a portion of silica undissolved. With biphosphate of soda it effervesces and melts into a globule, transparent and colourless while hot, but becoming opal coloured, and cracking in every direction when cold.

Its constituents were found to be as follow:

			Atoms.
Silica,	41·35	20·67	5
Alumina,	49·55	22	5·32
Sulphuric acid,	2·01	0·40	0·09
Lime,	1·105	0·31	0·07
Water,	4·85	4·31	1·04
	98·865		

If we allow for a little sulphate of lime, undoubtedly accidental, and a small excess of alumina, the constitution of the mineral is

5 atoms silicate of alumina,
1 atom water.

Hence the formula is $5\text{AlS}+\text{Aq}$.[*]

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[*] I think it exceedingly probable that the mineral discovered by Nordenskiöld, in a granite rock, at Helsingforss, in Finland, and to which he gave the name of *pyrargyllite*, is nothing else than an impure specimen of hydrous bucholzite. It is described as sometimes black, light, and shining, like sordawalite; and sometimes bluish, granular, and destitute of lustre. It sometimes occurs in pieces which have the aspect of a four-sided prism, with the edges truncated. It is often penetrated by scales of chlorite. Its specific gravity is 2·505. Its hardness from 3 to 3·5. Muriatic acid decomposes it completely. Its constituents, according to the analysis of Nordenskiöld, are:

		Atoms.
Silica,	43·93	21·96
Alumina,	28·93	12·85
Protoxide of iron,	5·30	1·18
Magnesia, with some manganese,	2·90	1·16
Potash,	1·05	0·17
Soda,	1·85	0·46
Water,	15·47	13·75
	99·43[*]	

This is equivalent to

1 atom protoxide of iron, magnesia, potash, and soda,
4·3 atoms alumina,
7·39 atoms silica,
4·66 atoms water.

So that the mineral consists of

4·3 atoms silicate of alumina,
4·66 atoms water,
1 atom tersilicate of iron, magnesia, potash, and soda.

[*] Berzelius' Jahr-Bericht, 1833, p. 174.

Sp. 15. *Halloylite.*

This mineral was first observed by M. Omalius d'Halloy, at Angleure, where it occurs in nodules, amid the collection of ores of iron, zinc and lead, which fill the cavities in the transition limestone of that country.

Halloylite is compact, and has a white colour; fracture conchoidal; lustre waxy. Soft enough to be scratched by the nail; slightly translucent on the edges; adheres strongly to the tongue.

When small pieces of it are put into water they become transparent, like the hydrophane, air is disengaged, and the weight is increased about a fifth part.

When calcined it loses from 26·5 to 28 per cent. of its weight, and becomes milk-white. When dried, but not calcined, it rapidly absorbs water when plunged into that liquid, or left in a humid atmosphere.

It is rapidly decomposed by sulphuric acid, which dissolves the alumina, and leaves the silica in a gelatinous state. Berthier analyzed it, and found its constituents as follow:

			Atoms.
Silica,	39·5	19·75	4
Alumina,	34·0	15·11	3·05
Water,	26·5	23·55	4·79
	100·0*		

The constituents are

4 atoms silica,
3 atoms alumina,
$4\frac{3}{4}$ atoms water.

We may perhaps consider halloylite as a compound of

2 atoms silicate of alumina,
1 atom bisilicate of alumina,
4 atoms water.

For when dried on the stove it loses a portion of its water, and retains rather less than 3 atoms, united to 4 silica and 3 alumina.

Sp. 16. *Pholerite.*

This is another hydrous silicate of alumina, which occurs in

Supposing these tersilicates to be foreign (as is probable) to the constitution of the mineral, it will be obviously composed of

1 atom silicate of alumina,
1 atom water.

* Ann. de Chim. et de Phys. xxxii. 332.

the coal formation of Fins (Allier) in France, occupying some fissures in the sandstone, slate, clay and ironstone.

It has a fine white colour, and is formed of small convex scales, having a pearly lustre. It is soft to the touch, and may be crushed between the fingers.

It adheres to the tongue. When plunged into water it disengages some air-bubbles; but does not exhibit the appearance of lenzinite. It forms a paste with water.

When heated it gives out water, but is infusible before the blowpipe per se.

According to the experiments of M. Guillemin,* to whom we are indebted for the only description of pholerite hitherto published, its composition in three different specimens analyzed, was as follows:

Silica, . .	42·925 .	41·65 .	40·750
Alumina, . .	42·075 .	43·35 .	43·886
Water, . .	15·000 .	15·00 .	15·364
	100	100	100

If we take the mean of these three analyses, the atomic constituents will be

		Atoms.
Silica, . .	20·72 .	1·54
Alumina, . .	19·15 .	1·42
Water, . .	13·44 .	1

These numbers approach pretty nearly

$1\frac{1}{2}$ atom silica,
$1\frac{1}{2}$ atom alumina,
1 atom water,

or 1 atom water united to $1\frac{1}{2}$ atom silicate of alumina. The formula will be $1\frac{1}{2}\mathrm{AlS}+\mathrm{Aq}$.

Sp. 17. *Worthite.*

This mineral was discovered in 1830 by M. Von Wörth, secretary to the mineralogical society of St. Petersburgh, in one of his mineralogical excursions. For the only account of it which I have had an opportunity of seeing, we are indebted to Dr. Hess.†

It has a considerable resemblance to diaspore in its external character.

It is white and translucent; has a foliated crystalline texture; but has hitherto been found only in rolled pieces destitute of any regular crystalline shape. Its plates have a lustre similar to that of cyanite. Specific gravity at least 3; hardness 7·25.

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* Ann. des Mines, xi. 489.

† Poggendorf's Annalen, xxi. 73.

When heated in a glass it becomes opaque, and gives out water, which has no reaction on vegetable blues, and when evaporated leaves no residue. With biphosphate of soda there is no distinct action. With borax it dissolves very slowly. With carbonate of soda it effervesces, but the assay does not melt completely in the strongest heat; the soda sinks into the charcoal and leaves a white frit. When moistened with nitrate of soda and strongly heated, it gives a beautiful dark blue.

Its constituents, as determined by the analysis of Dr. Hess, are as follow:

Silica,	40·58	41·00
Alumina,	53·50	52·63
Magnesia,	1·00	0·76
Water,	4·63	4·63
Peroxide of iron,	trace	
	99·71	99·02

Taking the mean of these two analyses, we have the atomic constituents of the mineral as follow:

		Atoms.
Silica,	20·39	5
Alumina,	23·58	5·78
Magnesia,	0·35	0·08
Water,	4·11	1

This approaches very nearly (including the magnesia with the alumina) to

5 atoms silicate of alumina,
1 atom hydrate of alumina.

Sp. 17. *Cyanite,*[*] or *Subsesquisilicate of Alumina.*

Disthene, kyanite, rhœtizite, sappare.

This mineral was first observed in Aberdeenshire in Scotland. Specimens of it were sent to Saussure by a Scottish mineral dealer, under the name of *sapphire.* Saussure read the name *sappare,* which was the origin of that appellation by which the mineral was at first distinguished. It has been observed only in primary rocks, and usually in mica slate.

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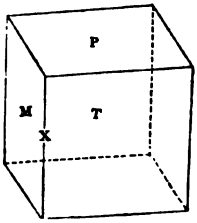
[*] From κυανος, *blue,* on account of its blue colour.

The colour is most commonly white, often passing into blue, sometimes inclining to green or grey. Frequently exhibits spots of Berlin blue elongated in one direction on a paler ground. Streak white.

It is usually crystallized in four or eight-sided prisms, which are mostly terminated irregularly. Its primary form is a doubly oblique prism.



P on M 93° 15′
P on T 100° 50′
M on T 106° 15′

as measured by Mr. W. Phillips on cleavage planes.

The obtuse edge of the prism X, is often replaced by a plane, which makes with M an angle of 140° 55′, and with T an angle of 145° 16′.

Texture foliated; transparent to translucent; hardness 6; specific gravity from 3·618 to 3·675.

Infusible before the blowpipe per se. With borax it fuses slowly into a transparent colourless glass.

It was analyzed by M. T. Saussure,[*] by Laugier[†], and by Klaproth.[‡] But the specimens selected for analysis by Arfvedson, seem to have been purest. He did not succeed in decomposing it by heating it with four times its weight of carbonate of potash, but caustic potash answered the purpose. He analyzed four specimens, the two last of which were from Norway. His results were as follow:[§]

Silica,	34·33	36·9	36·4	37·0
Alumina,	64·89	64·7	63·8	62·5
	99·22	101·6	100·2	99·5

The mean of these four analyses gives

			Atoms.
Silica,	36·66	18·33	1
Alumina,	63·97	28·43	1·55
	100·63		

This is obviously

1 atom silica,
1$\frac{1}{2}$ atom alumina.

The formula will be $Al^{1\frac{1}{2}}S$.

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[*] Jour. de Phys. 1793, ii. 13.
[†] Gehlen's Jour. iv. 538.
[‡] Beitrage, v. 10.
[§] Kong. Vetensk. Acad. Handl. 1821, p. 147.

Sp. 18. *Allophane.*[*]

This mineral was first observed about the end of 1815, by Messrs. Riemann and Roepert, at Saalfield in Thuringia. It was described and analyzed by Hoffmann and Stromeyer in 1816.[†] Since that period it has been met with at Sneeberg in Saxony, and in other places.

Allophane lines irregular cavities in a kind of marl. Its colour is commonly a light sky blue; sometimes it is green, brown, or yellow.

Fracture small conchoidal, or approaching to even; lustre waxy and splendent, internally; but externally the lustre is less.

From semi-transparent to translucent; very brittle.

Hardness 3; specific gravity from 1·852 to 1·889.

It has often a thin outer coating which has a greenish or bluish white colour, and is dull. It is occasionally accompanied by blue or green copper ore.

Before the blowpipe it speedily loses its colour and becomes white and opaque, while the flame is tinged green. Its bulk is a little diminished, but it does not melt per se. But by the heat produced by passing a stream of oxygen gas through a spirit lamp, it may be melted into a white opaque glass bead. With borax it fuses, with some frothing, into a transparent and almost colourless glass, having however, a slightly bluish green shade.

Its constituents, as determined by Stromeyer in three successive analyses, are as follow:

		Atoms.	
Silica,	21·922	10·96	3
Alumina,	32·202	14·31	3·91
Lime,	0·730	0·20	0·05
Sulphate of lime,	0·517		
Carbonate of copper,	3·058		
Hydrated peroxide of iron,	0·270		
Water,	41·301	36·71	10·005
	100·000		

The sulphate of lime, carbonate of copper, and hydrated peroxide of iron, are doubtless foreign bodies. We may (including the lime with the alumina) consider allophane as composed of

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[*] Probably named from *αλλος*, *high*, and *φαινω*, *to shine;* on account of its great internal lustre.

[†] Gilbert's Annalen, liv. 120.

3 atoms silica,
4 atoms alumina,
10 atoms water.

Perhaps the constitution of the mineral may be represented by

2 atoms silicate of alumina,
1 atom disilicate of alumina,
10 atoms water.

The formula will be $2AlS + Al^2S + 10Aq$.

If this be the true constitution, perhaps it would have been better to have referred allophane to the section which contains the zeolites or hydrous double salts of alumina.

Sp. 19. *Tuesite.*

This name has been given to a mineral from the new red sandstone on the banks of the Tweed, described and analyzed by my nephew, Dr. Robert D. Thomson.

Colour milk-white; opaque; lustre resinous, nearly dull; sectile.

Hardness 2·5; specific gravity 2·558 to 2·624.

Before the blowpipe assumes a light blue colour and becomes brittle. With carbonate of soda fuses into an opaque mass. With borax or biphosphate of soda fuses into a colourless glass bead.

Its constituents, as determined by the analysis of Dr. R. D. Thomson and Mr. Richardson, are

				Atoms.		
Silica,	44·300	43·80	22·15	2	2	6
Alumina,	40·400	40·10	17·95	1·62	—	—
Protoxide of iron,	—	0·945	—	—	—	—
Lime,	0·755	0·64	0·21	·014	1⅔	5
Magnesia,	0·500	0·55	0·20	·012		
Water,	13·500	14·21	12·	1·08	1	3
	99·455	100·245				

Including the lime and magnesia with the alumina, it is $3AlS + 2AlS^{1\frac{1}{2}} + 3Aq$.

It makes excellent slate pencils.

Sp. 20. *Nacrite,*† or *Anhydrous Bisilicate of Alumina.*

Talcite, earthy talc.

This mineral occurs usually in mica slate, taking the place of the mica; so that the rock in which it occurs constitutes a mixture of nacrite and quartz. The rock in which *nacrite* occurs at Brunswick, Maine, North America, is a compound of nacrite, granular quartz, and iron pyrites. In the county of Wicklow, it is found crystallized in granite.

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* Named from the river Tweed, in Latin *Tuesa.*

† Named from its pearly lustre.

Colour silvery white or light greenish white.

It usually consists of small scales which are very soft, flexible but not elastic. In the county of Wicklow it occurs in long four-sided prisms, with angles of about 89° and 91°. These crystals are intermixed with scales of uncrystallized nacrite.*

Lustre splendent, silky; translucent.

Hardness 2·75; specific gravity from 2·788 to 2·793.

After ignition it becomes silvery white; but still retains its splendid lustre.

The following table exhibits the constituents of various specimens of nacrite which have been subjected to analysis.

	†	‡	§
Silica,	64·440	46·000	60·20
Alumina,	28·844	35·200	30·83
Lime,	—	9·608	—
Protoxide of manganese,	—	3·944	—
Protoxide of iron,	4·428	2·880	3·55
Water,	1·000	2·000	5
	98·712	99·632	99·58

The atomic proportions in the crystals which constitute the second analysis in the table, are as follows:

	Atoms.
Silica,	23
Alumina,	11·2
Lime,	2·74
Protoxide of manganese,	0·87
Protoxide of iron,	0·64
Water,	1·77

As neither of the other specimens contain lime or protoxide of manganese, there can be little doubt that these bodies in the crystals are accidental. Nor can we admit the iron or water to enter as essential constituents, on' account of their great difference in quantity in the various specimens examined. Hence nacrite must consist essentially of silica and alumina, and the proportions are very nearly

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* These crystals were brought to me by Mr. Doran, an Irish mineral dealer, as crystals of Andaluzite. A slight examination showed that they could not be andaluzite, and a chemical analysis ascertained their identity with nacrite.

† The specimen was from Brunswick, Maine. By my analysis.

‡ The crystals from Wicklow. Analyzed by Dr. Short.

§ Yellow earthy talc from Merowitz, analyzed by John. Jour. des Mines, xxiii. 384.

2 atoms silica,
1 atom alumina,

or nacrite seems to be a bisilicate of alumina.

Sp. 21. *Fuller's Earth*, or *hydrous Bisilicate of Alumina.*

Walkerde.

This mineral has got its name from being employed by fullers in scouring woollen cloths. It occurs in the green sand and oolitic formations in beds, often of considerable thickness. It varies somewhat in its characters, and probably also in its composition. But that variety, which from its chemical composition I place here, possesses the following characters:

Colour dull greenish grey.

Texture earthy; fracture uneven; opaque; rather tough; sectile; feel soapy; lustre dull; hardness 1; specific gravity 2·4448; adheres very slightly to the tongue. When put into water it falls to powder.

Before the blowpipe fuses into a grey opaque enamel. With carbonate of soda it effervesces and melts into a bead; transparent and nearly colourless while hot, but becoming opaque and buff coloured when cold. With borax it does not unite nor tinge the transparent globule of borax with any colour. With biphosphate of soda it forms an opaque frit, half fused.

Its constituents, determined by my analysis, are as follow:

			Atoms.
Water,	24·95	22·17	2·16
Silica,	44·00	22	2·14
Alumina,	23·06	10·25	1
Lime,	4·08	1·16	0·11
Magnesia,	2·00	0·80	0·07
Protoxide of iron,	2·00	0·44	0·04
	100·09		

If we allow that the lime, magnesia, and protoxide of iron are in the state of silicates, and if from their small quantity they be considered as only accidental constituents, then the specimen of fuller's earth here described, is a compound of

2 atoms silica,
1 atom alumina,
2 atoms water;

or it is a hydrous bisilicate of alumina. Its formula will be $AlS^2 - 2Aq$.

I received from Dr. Holme of Montreal, in 1833, a mineral, which he informed me constitutes a rock in Magdalen islands, situated in the Gulf of St. Lawrence.

It has a good deal of resemblance to fuller's earth. Its colour is greenish grey, with here and there an admixture of brownish yellow. It is opaque; soft enough to be scratched by the nail; texture earthy; dull; specific gravity 2·517. Its constituents were found to be:

		Atoms.	
Silica,	47·65	23·82	5·81
Peroxide of iron,	20·50	4·10	1
Alumina,	17·70	7·84	1·91
Lime,	2·20	0·62	0·15
Water,	11·05	9·82	2·4
	99·10		

This is very nearly

2 atoms bisilicate of alumina,
1 atom bisilicated peroxide of iron,
2½ atoms water.

It is therefore fuller's earth, combined with half an atom of bisilicated peroxide of iron. Its symbol is

$$2AlS + \underset{\cdot}{f}S^2 + 2\tfrac{1}{2}Aq.$$

Sp. 22. *Davidsonite.*

This mineral was discovered by Dr. Davidson, Professor of Natural History in the Marischal College, Aberdeen, in the granite quarry of Rubislaw, near Aberdeen, constituting a detached mass in the granite.

Colour greenish yellow.

Texture foliated; cleaves in the direction of the faces of a four-sided prism, with angles of 86° and 94°. The base of the prism is oblique, and inclined at an angle of about 100°, but it is not smooth enough to admit of accurate measurement.

Translucent; easily frangible; brittle.

Hardness 6·5; specific gravity 2·3629.

Before the blowpipe per se, becomes white, but does not fuse. With carbonate of soda fuses imperfectly into a white enamel. With borax it fuses into a transparent colourless glass, having a silica skeleton in the centre. With biphosphate of soda the same. It is intimately mixed with thin plates of mica, from which it is difficult to free it. Hence the lime, oxide of iron, and magnesia, which are found in variable proportions on analyzing it. When pure the constituents seem to be:

		Atoms.	
Silica, .	66·59 .	33·29 .	2·33
Alumina,	32·12 .	14·27 .	1
Water, .	1·30		
	100·01		

It is a compound of

$2\frac{1}{3}$ atoms silica,
1 atom alumina.

Sp. 23. *Lenzinite.*

This mineral was first described and analyzed by John, who named it after Lenzius, a German mineralogist of his acquaintance.* It was first observed at Kall, in Eifeld. It was afterwards found in the neighbourhood of St. Sever, and this variety was described by M. Leon Dufour, and analyzed by Pelletier.† It is this last variety which, from its chemical constitution, is placed here.

It is most commonly met with in amorphous masses, from the size of the fist to that of the head. It is much lighter than limestone, and covered externally with a yellowish brown coating of oxide of iron. Internally it is of a fine dead colour.

It is an opaque, homogeneous, compact substance, having a fine grain, soft and soapy to the touch. It is capable of receiving a polish by being rubbed with the finger.

Specific gravity from 1·8 to 2·1, according to John.

Adheres strongly to the tongue; sectile; fracture conchoidal; dull.

When dipt into water and then held near the ear, it crackles remarkably, but does not split like the argillaceous lenzinite of John.

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* Ann. des Mines, iv. 145.

† Annals of Philosophy (second series), viii. 391.

When heated it becomes hard, but not sufficiently so to scratch glass.

Its constituents, according to Pelletier, are

		Atoms.	
Silica,	50	25	2·55
Alumina,	22	9·77	1
Water,	26	21·95	2·34
	98		

The constituents are

2½ atoms silica,
1 atom alumina,
2⅓ atoms water.

But the specimens of lenzinite analyzed by John were composed of

Silica,	37·5	39
Alumina,	37·5	35·5
Water,	25·0	25
Lime,	trace	0·5
	100	100

The mean of these two analyses give us

	Atoms.	
Silica,	19·12	1·17
Alumina,	16·22	1
Water,	22·22	1·37

This nearly comes to

1 atom silica,
1 atom alumina,
1 atom water;

so that John's lenzinite is a simple hydrous silicate of alumina.

From this it is obvious that either the two minerals are essentially distinct, or lenzinite is not a chemical compound. Indeed, I think there can be little doubt that the *lenzinite* of John is merely a variety of Halloylite.

Sp. 24. *Quatersilicate of Alumina.*

In the year 1826, among a number of minerals sent me from Mexico, there was one which was ticketed "Piedraen Barras? Dipiro de Hauy? De cimophan." This ticket, without giving us any information about the locality of the mineral, gives us the views of the gentlemen who sent it respecting its nature.

Its colour is yellowish white.

Its structure is radiated; for it is composed of imperfect oblique four-sided prisms, diverging slightly, as if from a centre. The surface of the prisms is streaked longitudinally, but no cleavage is perceptible by which information might be got respecting its primary form.

Lustre pearly. When pounded it separates into pearl coloured flakes, having somewhat the appearance of talc; lustre shining.

Opaque, or only very slightly translucent on the edges, when in very thin fragments.

Hardness at present 5; but when it was first put into my cabinet it was softer than calcareous spar, or under 3.

Specific gravity 2·688.

Infusible before the blowpipe per se.

The specimen was much mixed with iron pyrites.

Its constituents were found to be

		Atoms.	
Silica, . .	72·52 .	36·26 .	3·99
Alumina, .	20·44 .	9·08 .	1
Peroxide of iron,	2·40 .	0·48 .	0·05
Water, . .	3·40 .	3·02 .	0·33
	98·76		

The peroxide of iron and water, from the minuteness of their quantity, are probably only accidental ingredients. The mineral is composed of

4 atoms silica,
1 atom alumina,

or it is a quatersilicate of alumina. Its formula will be AlS^4.

Claystone is not unfrequently a quatersilicate of alumina, more or less pure. This will be evident from the following analysis of a specimen from Germany.

Its specific gravity was 2·451. Its constituents were found to be

		Atoms.	
Silica, . .	72·920 .	36·46 .	5·17
Alumina, . .	15·852 .	7·04 .	1
Protoxide of iron,	3·080 .	0·68 .	0·09
Lime, . .	2·000 .	0·57 .	0·08
Potash, . .	0·504 .	0·08 .	0·01
Soda, . . .	1·640 .	0·41 .	0·06
Water, . .	4·000 .	3·55 .	0·50
	99·996		

It is obviously composed of

1 atom quatersilicate of alumina,
¼ atom quatersilicates of iron, lime, potash and soda.

Sect. 3. *Double Anhydrous Aluminous Salts.*

These saline minerals are very numerous, amounting to no fewer than thirty-seven. They are easily distinguishable from the hydrous double aluminous silicates or *zeolites*, as they have been called, by not frothing when exposed to the action of the blowpipe.

Sp. 1. *Cryolite*, or *Soda Fluate of Alumina.*

This mineral has been hitherto found only at Arksat, an arm of the sea, about thirty leagues from the colony of Juliana Hope, in West Greenland. From this spot it was brought to Copenhagen, where it lay for eight or nine years unnoticed, till it was analyzed by Abilgaard, about the end of the last century.

Colour white, sometimes reddish or brownish; streak white.

It has not been observed in crystals; but it cleaves parallel to the faces of a right rectangular prism, which constitutes its primary form.

Translucent, or semitransparent.

Lustre vitreous, slightly inclining to pearly upon the faces corresponding to the base of the prism; brittle.

Hardness 2·25; specific gravity 2·949.

Melts when held to the flame of a candle.*

It was analyzed by Klaproth† and Vauquelin,‡ and more recently by Berzelius,§ who showed it to be anhydrous. From 100 parts of cryolite he obtained 24·4 alumina, and 101 fused sulphate of soda, equivalent to 44·89 grains of soda. As the mineral is neutral, these bases must be saturated with fluoric acid (the only acid found in it). Hence it is composed of

Fluate of alumina,	37·055
Fluate of soda,	58·915
	96·870

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* Hence the name from κρυος, *cold*, because it melts like *ice* when applied to the flame of a candle.

† Beitrage iii. 207.

‡ Hauy's Mineralogie, ii. 158.

§ Kong. Vet. Acad. Handl. 1823, p. 315.

Now this approaches very nearly to
1 atom fluate of alumina,
1 atom fluate of soda.

The fluate of alumina and fluate of soda, when separate, are each soluble in water, but when mixed they combine and become insoluble. Hydrate of alumina, when mixed with fluate of soda in solution, carries off the whole acid and one-half of the soda, leaving the other half in a caustic state.

Sp. 2. *Topaz*, or *Fluosilicate of Alumina.*

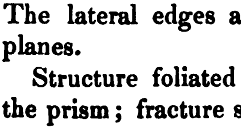
Physalite, pyrophysalite.

The name *topaz*, derived from an island in the Red Sea,* where the ancients used to find topazes, was applied by them to a mineral quite different from the modern topaz. Our topaz they seem to have distinguished by the name of *chrysolite.*

The *topaz* of the moderns is found only in primary rocks; most commonly granite. The finest crystals come from the Uralian and Altai mountains, and Kamschatka; from Brazil, where they usually occur in loose crystals; from Mucla, in Asia Minor. They occur also at Botany Bay, in Germany, in Cornwall, in the mountainous tract at the western extremity of Aberdeenshire, and in the Down mountains, in Ireland.

Colour white,† yellow, green, blue; generally pale.

It occurs both massive and crystallized. The primary form of the crystal is a right rhombic prism.



M on M′ 124° 22′, according to the measurement of Mr. W. Phillips. The angles of the base P are usually replaced by tangent planes causing the prism to terminate in a four-sided pyramid. Sometimes the obtuse angles are replaced by two planes, in which case the terminal plane P is not quite obliterated; so that the crystal terminates in a truncated six-sided pyramid. The faces of the prism are usually striated longitudinally. The lateral edges are frequently replaced by one or more planes.

Structure foliated; the foliæ at right angles to the axis of the prism; fracture small conchoidal, or uneven.

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* It got its name from τοπαζω, *to seek*, because the island was often surrounded with fog, and therefore difficult to find. See Plinii, lib. 37, c. 8.

† The Mina Nova topaz, from Brazil, is as colourless as rock crystal.

Lustre vitreous; from splendent to glimmering, or even dull.

Transparent, to translucent on the edges.

Hardness 8; specific gravity, as determined by Mr. Lowry, 3·641. Haidinger states it at 3·499.

In a strong heat the faces of crystallization, but not those of cleavage, become covered with small blisters, which, however, immediately crack. With borax it melts slowly into a transparent glass. Its powder gives a green colour to the tincture of violets.

Those crystals which possess different faces of crystallization at opposite ends of the crystal, acquire different kinds of electricity at the two extremities, when heated. By friction topaz acquires positive electricity.

The variety called *pyrophysalite*, which occurs at Finbo, three-quarters of a Swedish mile from Fahlun, embedded in gneiss, has a white colour with a slight shade of green. It is found in very large crystals. Its structure is foliated in one direction, and splendent. The cross fracture is uneven and glimmering. It is translucent on the edges. In its other properties it agrees with topaz.

Klaproth first ascertained the true composition of this mineral. It was afterwards analyzed with much care by Berzelius. The following table exhibits the constituents according to the analysis of these chemists:

	*	†	‡	§	‖
Silica, . . .	35	44·5	34·24	34·01	34·36
Alumina, . . .	59	47·5	57·45	58·38	57·74
Fluoric acid, . .	5	7	7·75	7·79	7·77
Oxide of iron, . .	—	0·5	—	—	—
	99	99·5	99·44	100·18	99·87

If we take the mean of Berzelius's three analyses, which correspond so closely with each other, we have the atomic proportions of these constituents, as follow:

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* Klaproth, Beitrage, iv. 166. The Saxon topaz.

† Klaproth. Ibid. The Brazilian topaz.

‡ Berzelius, Afhandlingar, iv. 236. The Saxon topaz.

§ Berzelius. Ibid. The Brazilian topaz.

‖ Berzelius. Ibid. The pyrophysalite.

		Atoms.
Silica,	17·1	2·66
Alumina,	25·71	4
Fluoric acid,	6·21	0·96

The silica is rather less than three atoms; but if we take into account the difficulty of obtaining the whole silica in a mineral containing fluoric acid, and that the amount obtained by Klaproth exceeds that of Berzelius, we may perhaps, without much hesitation, admit that topaz is a compound of

3 atoms silicate of alumina,
1 atom fluate of alumina.

Sp. 3. *Pycnite*, or *Schorlous Beryl*.

Schorlite, stangenstein.

This mineral was originally considered by Werner as a variety of beryl. Hauy united it with topaz; but without sufficient reason. It is found at Altenberg, in Saxony, forming one of the constituents of a rock composed chiefly of quartz and mica. Other localites have been pointed out in Bavaria, Bohemia, France, Norway, and Siberia.

Colour dull yellowish, or reddish white.

It is found in long six-sided prisms, which are striated longitudinally. The prisms are often closely aggregated laterally, and exhibit transverse rents but do not appear to possess a regular structure.

Translucent.

Brittle, and may be easily broken across the prism. This renders it difficult to determine its hardness; but it scratches quartz.

Lustre shining, resinous.

Specific gravity, as determined by Bucholz, from 3·503 to 3·530.

Before the blowpipe on charcoal it does not fuse. With borax it melts slowly into a transparent glass. It becomes electric by exposure to heat.

Its constituents, as determined by the analysis of Berzelius, are as follow:—

			Atoms.
Silica,	38·43	19·21	5·93
Alumina,	51·00	22·66	7
Fluoric acid,	8·84	7·08	2·18
	98·27*		

---

* Afhandlingar, iv. 251.

These atomic proportions correspond with
6 atoms silicate of alumina,
1 atom bifluate of alumina.
Which must therefore be considered as exhibiting the constitution of this mineral.

Sp. 4. *Amblygonite.**

This mineral has been hitherto observed only at Chursdorf, near Penig, in Saxony, where it occurs in a granite along with tourmaline and topaz. It was first recognised as a peculiar species by Breithaupt.

Colour greenish white, passing into light mountain and celandine green; streak white.

It occurs in rhombic prisms of 106° 10′ and 73° 50′, which are rough externally. It cleaves parallel to the faces of the prism with brilliant surfaces. But the position of the base of the prism, whether right or oblique, has not been ascertained.

Fracture uneven.

Lustre vitreous, inclining to pearly.

Semitransparent to translucent.

Hardness 6; specific gravity, as determined by Breithaupt, from 3 to 3·04.

Before the blowpipe it is easily fusible, intumesces, and is converted into a white enamel.

Breithaupt sent a specimen of it to Berzelius, who analyzed it, and in a letter to Breithaupt, says, that it contains 11 per cent. of lithia, and that the other constituents are alumina, and phosphoric acid, with a little fluoric acid;† and in his paper on the Mineral System, published in 1824,‡ he states the constituents to be $L^2P+Al^4Ph^3$. This formula turned into numbers, and using Berzelius's atomic weights, gives us

			Atoms.
Phosphoric acid,	35·69	7·93	1·52
Alumina,	25·69	11·41	2·19
Lithia,	9·11	5·20	1
	70·49		

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* Named probably from αμϐλυς, *blunt*, and γωνη, *an angle.*

† Gilbert's Annalen, lxv. 322.

‡ Kong. Vet. Acad. Handl., 1824, p. 136.

This is obviously

2 atoms diphosphate of alumina,
1 atom diphosphate of lithia.

Hence the formula will be $2Al^2\dot{P}h+L^2\dot{P}h$.

Sp. 5. *Fibrolite.*[*]

This mineral is found accompanying crystals of corundum in the Carnatic, and is a component part of the granite, which is the matrix of the corundum of China. It was first distinguished as a peculiar species by Count Bournon.

Colour white, or dingy grey.

Texture fibrous. Hence the name.

Cross fracture compact.

Seldom crystallized. But Count Bournon met with it in right prisms with rhombic bases, having angles of 100° and 80°.

Rather harder than quartz.

Specific gravity, according to Bournon, 3·214.

Internal lustre vitreous.

It acquires negative electricity by friction. When two pieces are rubbed they give out a dark red phosphorescent light.

Its constituents, as determined by the analysis of Chenevix, are

			Atoms.
Silica,	38	19	3
Alumina,	58·25	25·88	4·08
Trace of iron.			
	96·25		

These atomic numbers correspond with

2 atoms silicate of alumina,
1 atom disilicate of alumina.

The formula is $2AlS+Al^2S$.

Sp. 6. *Nepheline.*

Sommite, davyne,[†] covellinite, beudontite.

This mineral has been hitherto found only in the cavities of a granular limestone in that part of Vesuvius called Monte Somma, and in the lava of Capo di Bove, near Rome.

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[*] Named by Bournon from its *fibrous* structure.

[†] From the experiments of Mitcherlich it appears, that the davyne of Monticelli and Covelli agrees in the crystalline form, and in its chemical constitution with nepheline, if we except the presence of a little chloride of calcium. See Ann. des Mines (third series), iv. 213.

Colour greyish, or greenish white; streak white.

It occurs in grains, or in small regular six-sided prisms, of which the terminal edges are sometimes replaced. The regular six-sided prism is considered as the primary form.

Fracture conchoidal; surface smooth and even.

Lustre vitreous; transparent to translucent; brittle.

Hardness 2·5; specific gravity, as determined by Roget and Dumas, 3·270.[*]

Before the blowpipe on charcoal the edges are rounded off. It yields a colourless and vesicular glass, but cannot be melted into a perfect globule.

Fragments of it thrown into nitric acid lose their transparency and assume a nebulous appearance. This suggested to Hauy the name *nepheline*.[†]

Its constituents, by the analysis of Arfvedson, are the following:—

		Atoms.	
Silica,	44·11	22·05	4·31
Alumina,	33·73	15	2·93
Soda,	20·46	5·11	1
Moisture,	0·62		
	98·92[‡]		

This corresponds with

3 atoms silicate of alumina,
1 atom silicate of soda.

The formula is $3\text{AlS}+\text{NS}$.

Sp. 7. *Sodalite.*

Hauyne, noseane, spinellane.

This mineral was discovered by Sir Charles Giesecké at Kanerdluersuk, a narrow tongue of land in latitude 61°, West Greenland, where it occurs in a mica slate. It was afterwards observed on the slope of Mount Vesuvius by Count Borkowsky.

Colour green, greenish white, passing into greyish and snow white; streak white.

Massive and crystallized in rhomboidal dodecahedrons, which has been considered as the primitive form. But the sodalite of Vesuvius when crystallized has usually 18 faces; namely, those of the cube (elongated) and those of the dodecahedron; and in some of the crystals all the edges are replaced by tangent planes.[*]

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[*] Annals of Philosophy (second series), iii. 392.

[†] From νεφελη, a cloud.

[‡] Kong. Vetens. Acad. Handl., 1821. p. 150.

Fracture conchoidal, uneven.

Lustre vitreous; translucent; brittle; hardness 5·75; specific gravity from 2·295 to 2·378.

Before the blowpipe it melts with intumescence, and the development of air bubbles into a colourless glass bead. With borax it melts with difficulty, and only when added in small proportions.

Soluble in muriatic acid and in nitric acid.

The constituents of this mineral, according to the different analyses hitherto made, are as follow:—

	†	‡	§	‖	¶
Silica, . . .	38·52	36·00	44·87	33·75	50·98
Alumina, . .	27·48	32·00	23·75	35·50	27·64
Lime, . . .	2·70	—	—	—	—
Protoxide of iron, .	1·00	0·25	0·12	—	—
Soda, . . .	25·50	25·00	27·50	26·23	20·96
Muriatic acid, .	3·00	6·75	—	5·30	1·29
Volatile matter, .	2·10	—	—	—	—
	100·30	100	96·24	100·78	100·87

If we take the mean of Ekeberg's results and my own, we find sodalite is composed of the following atomic quantities:—

		Atoms.
Silica	18·63 .	3
Alumina,	13·21 .	2·12
Soda, .	6·31 .	1·01
Muriatic acid,	1·08 .	0·17

It is obvious that the constituents are

2 atoms silicate of alumina,
1 atom silicate of soda,
$\frac{1}{8}$th atom muriate of alumina.

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[*] See Haidinger's description, Edinburgh Journal, xiii. 222.

[†] By my analysis. Specimen from Greenland.

[‡] Ekeberg. Specimen from Greenland.

[§] Borkowski, Gilbert's Annalen, lxiii. 382. The loss was doubtless muriatic acid. From Vesuvius.

[‖] Arfvedson, Kong. Vet. Acad. Handl., 1821, p. 153. From Vesuvius.

[¶] Wächtmeister, Ann. des Mines, xii. 284.

Probably the last ingredient is only accidentally present. If so, the formula will be 2AlS+NS.

The mineral analyzed by Wāchtmeister seems to have been a nepheline, or at least to approach the nature of that mineral. Arfvedson's analysis approaches the first two. Borkowski's differs from all the rest.

Sp. 8. *Idocrase.*[*]

Egrane, loboite, vesuvian, wiluite, frugordite.

This mineral was first observed in the lava from Vesuvius and Etna; but it was afterwards found in primary rocks in various parts of the world. That found at Egra, in Bohemia, which is in much larger prisms and less perfectly crystallized, got the name of *egrane*. Nordenskiöld gave the name of *frugordite* to a variety occurring in a lime quarry at Frugord, in Finland.

Colour various shades of brown, passing into leek green, pistachio green, olive green, and oil green; streak white.

It is found occasionally massive, but most commonly crystallized. The primary form is a right square prism. The lateral edges of the prism are frequently replaced by tangent planes, which sometimes increase so much as nearly to obliterate the primary planes of the prism. These new faces make angles of 135° with the primary faces of the prism. The terminal edges of these new faces of the prism are often replaced by new planes making angles of about 127° with these lateral faces. These new faces when they obliterate the base of the prism, constitute a four-sided pyramid with which the prism terminates. But I have never observed this pyramid complete. A portion of the base of the prism always remains.

Lustre vitreous, but often inclining to resinous, especially in the variety called *egrane;* fracture uneven.

Semitransparent to translucent on the edges; refracts doubly.

Hardness 6; specific gravity from 3·349 to 3·399.

Before the blowpipe fuses with ebullition into a yellowish transparent glass.

Idocrase was analyzed by Klaproth,[†] Borkowski,[‡] and

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[*] From *ειδω*, *I see*, and *κρασις*, *mixture*. Because its crystalline forms have a considerable resemblance to that of several other minerals.

[†] Beitrage, ii. 32.

[‡] Annals of Philosophy, xv. 146.

Nordenskiöld.[*] But the most elaborate analyses are those made by Magnus in 1831.[†] The following table exhibits the result of these analyses :—

	‡	§	‖	¶
Silica, ...	37·359	37·178	38·519	37·658
Alumina, . . .	23·530	18·107	20·063	17·695
Protoxide of iron, .	3·992	4·671	3·420	6·489
Lime, . . .	29·681	35·791	32·411	31·896
Magnesia, . . .	5·208	0·773	2·987	4·537
Protoxide of manganese,		1·495	0·018	0·499
Potash, . . .	—	—	—	trace
	99·770	98·015	97·418	98·774

The mean of these four analyses gives us the following atomic proportions of the constituents :—

	Atoms.
Silica, . .	18·77
Alumina, . .	8·82
Protoxide of iron,	1·03
Lime, . .	9·27
Magnesia, . .	1·10
Protoxide of manganese,	0·15

The bases amount to 20·37 atoms, and therefore exceed the silica by 1·6 atom. But the magnesia and protoxide of manganese vary so much in the different analyses that we cannot avoid considering them as accidental. If so idocrase consists of simple silicates, and including the protoxide of iron along with the alumina, it is obviously

1 atom silicate of alumina,
1 atom silicate of lime.

Its formula is $AlS+CalS$.

Sp. 9. *Grossularite,*[**] or *Green Garnet.*

This mineral was first observed in Siberia in the year 1790, by Councillor Laxman, during his journey through that country, and was first made known to mineralogists by Pallas in the fifth volume of his *New Nordische Beytrage*, published in 1793. It was named by Werner from some resemblance which he fancied he perceived between it and a *green gooseberry*.

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[*] Bidrag, p. 80. [†] Poggendorf's Annalen, xxi. 50.

[‡] The specimen was from Vesuvius.

[§] The specimen was from Slatoust in the Uralian mountains.

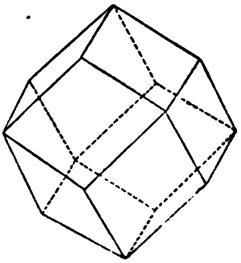
[‖] The specimen was from the Bannat.

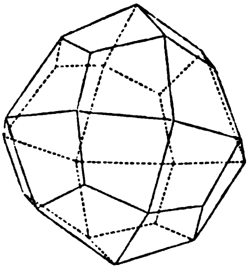
[¶] The specimen was from Egg. The analysis was conducted by fusing the mineral which renders it soluble in acids. It was then dissolved in muriatic acid.

[**] From its resemblance in colour to a green gooseberry.

Colour asparagus green.

Always in crystals. The primary form, is the rhombic dodecahedron, the faces of which are inclined to each other at angles of 120°. But hitherto that primary form has scarcely been observed in the grossularite. The form which it usually assumes is a twenty-four-sided almost spherical crystal, usually known among mineralogists by the name of *leucite crystal*. It will be obtained when the edges of the primary dodecahedron are replaced by tangent planes, and when these planes increase in size so much as to obliterate the original faces of the primary crystal. In general the original faces are not quite obliterated.





Lustre resinous, dull to shining.

Fracture between conchoidal and uneven.

Translucent.

Hardness 6·75; specific gravity 3·372, as determined by Klaproth, to 3·64, as determined by Trollé Wăchtmeister.

It loses no weight, nor does it change its appearance after ignition. Before the blowpipe thin splinters of it have their edges rounded off, but it does not completely fuse.

The following are the constituents of a specimen of grossularite from Kamtschatka, analyzed by Trollé Wăchtmeister:

		Atoms.
Silica, . .	40·55	20·27
Alumina, . .	20·10	8·93
Protoxide of iron,	5·00	1·11
Protoxide of manganese,	0·48	0·10
Lime, . .	34·86	9·95
	100·99*	

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* Kong. Vet. Acad. Handl., 1823, p. 141.

The atoms of the bases amount to 20·09, while those of silica are 20·27. It is evident from this that grossularite consists of simple silicates. Uniting the protoxide of iron to the alumina it becomes very nearly equal to the atoms of lime. Hence the mineral must be a compound of

1 atom silicate of alumina,
1 atom silicate of lime.*

This is precisely the constitution of idocrase. Yet the crystalline shape, and the hardness of the two minerals differ as much as those of arragonite do from calcareous spar.†

Sp. 10. *Melanite*,‡ or *Black Garnet.*

This mineral was observed first at Frescati near Rome, and at Monté Somma near Naples, and was arranged sometimes with garnet and sometimes with tourmalin, till Werner gave it the name of melanite (from its colour), and constituted it a peculiar species. Since that time it has been observed in various other localities, particularly in Bohemia and the United States of America.

Colour velvet black; sometimes inclining to greyish black.

It is usually crystallized. The primary form is the rhomboidal dodecahedron or garnet crystal. But in every specimen which I have seen, the edges of the dodecahedron are replaced by tangent planes, making a twenty-four sided figure similar to that of grossularite.

The lustre is rather inclined to resinous. When the sur-

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* Cyprine from Tellemarken, in Norway, is merely a variety of grossularite. Its colour is green, and its specific gravity 3·2278. The colour has been ascribed to copper, but I could not detect a particle of that metal in it. Mr. Richardson analyzed it in my laboratory, and obtained,

		Atoms.
Silica, . .	38·80 .	19·4
Alumina, . .	20·40 .	9·06
Protoxide of iron,	8·35 .	1·85
Lime, . .	32·00 .	9·14
	99·55	

These numbers approach so nearly to the analysis of Trollé Wächtmeister, that no doubt can exist respecting the identity of the two minerals analyzed.

† Were we to adopt the cube as the primary form we might deduce from it the crystals of both species. But the suite of crystals belonging to each is very different.

‡ From μελας, *black.*

face is smooth it is shining, when rough it is dull, or at most only glistening.

Fracture flat and imperfect conchoidal; opaque.

Hardness 6·75; specific gravity from 3·157 to 3·730.

Not altered by ignition. Before the blowpipe the edges are rounded off, but it cannot be fused into a globule. The constituents of a very pure specimen of melanite from Arendal analyzed by Trollé Wāchtmeister, are as follow:

		Atoms.
Silica, . .	42·450 .	21·22
Alumina, . .	22·475 .	9·99
Protoxide of iron,	9·292 .	2·06
Protox. of manganese,	6·273 .	1·39
Magnesia, . .	13·430 .	5·37
Lime, . .	6·525 .	1·86
	100·445*	

The atoms of the bases amount to 20·67, while the atoms of silica are 21·22. Hence the mineral consists of simple silicates. Of these bases the alumina constitutes very nearly one half. Hence the constituents are

1 atom silicate of alumina,

1 atom ($\frac{23}{46}$ magnesia+$\frac{9}{46}$ oxide of iron+$\frac{8}{46}$ lime+$\frac{6}{46}$ oxide of manganese) combined with one atom of silica. The formula is

$$AlS+(\tfrac{23}{46}Mg+\tfrac{9}{46}\underline{f}+\tfrac{8}{46}Cal+\tfrac{6}{46}\underline{mn})S.$$

The magnesia, oxide of iron, lime, and oxide of manganese, are to each other nearly as the numbers 4, $1\frac{1}{2}$, $1\frac{1}{3}$, 1.

Dark reddish brown garnet (what is usually distinguished by the name of *common garnet*) is perhaps a more decided chemical compound than the melanite, and the true type of this species.

Its colour is dark red or reddish brown. Its specific gravity varies from 4·236 to 3·90. It has the regular rhomboidal dodecahedral form which characterizes the garnet. Its constituents, determined by the analysis of Wāchtmeister,† are

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* Kong. Vet. Acad. Handl., 1833, p. 138. Its specific gravity was 3·157.

† Kong. Vet. Acad. Handl., 1823, p. 122.

	*	†	‡
Silica,	40·60	42·51	39·66
Alumina,	19·95	19·15	19·66
Protoxide of iron,	33·93	33·57	39·68
Protox. of manganese,	6·69	5·49	1·70
Lime,	—	1·07	—
	101·17	101·79	100·70

Taking the mean of these three analyses, we have the atomic proportions of the constituents of common garnet as follow:

	Atoms.
Silica,	20·46
Alumina,	8·70
Protoxide of iron,	7·94
Protoxide of manganese,	1·02
Lime,	0·30

The atoms of silica are 20·46, while those of the bases amount only to 17·96. Thus there is an excess of 2½ atoms of silica. This excess is probably accidental, for it does not hold with garnets in general. If we include the oxide of manganese along with the oxide of iron, the atoms of oxide of iron are very nearly equal to those of alumina. Hence the constituents of common garnet are

1 atom silicate of alumina,
1 atom silicate of iron.

Sp. 11. *Garnet.*

Precious garnet, almandine, aplome, greenlandite, pyrenaite, carbuncle of the ancients.

This important mineral varies so much in its colour, specific gravity, and chemical constitution, that there cannot be a doubt that it is for the most part a mixture of various minerals having the same crystalline form but a different chemical constitution. The minerals, by the mixture or combination of which it is formed, are three, namely,

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* The specimen from Engsö. The colour dark red, inclining to violet and muddy. Leucite crystal. Specific gravity 4·236.

† From New York. In regular rhombic dodecahedrons. Colour violet red; specific gravity 3·90.

‡ From Fahlun. Colour dark reddish brown. Occurs in very large crystals, weighing sometimes 10 or 12 pounds. Specific gravity 4·2, analysis by Hisinger. Afhandlingar, 4·385.

1 Grossularite, composed of $AlS+CS$.
2 Common garnet, composed of $AlS+\underline{f}S$.
3 Colophonite, of . . $CS+\underline{f}S$.

The consequence of this mixture is, that garnet consists of three different silicates in various proportions; namely,

1 Silicate of alumina,
2 Silicate of lime,
3 Silicate of iron,

And in some cases there is a fourth silicate present, namely,

4 Silicate of manganese.

The colour of the precious garnet (*almandine*, or *greenlandite*) is always red; of the common garnet, reddish, yellowish, greenish, or blackish brown; of pyrope, blood red.

Garnet occurs most commonly crystallized, and the primary form is the rhomboidal dodecahedron, figured in page 261. The edges are often replaced by tangent planes, which produce ultimately the leucite crystal of 24 trapezoidal faces. These two shapes often appear together constituting a crystal with 36 faces.

Structure foliated and the cleavage faces parallel to those of the primary form. Fracture uneven or conchoidal.

Lustre vitreous, in some varieties inclining to resinous.

Transparent to translucent; sometimes opaque or nearly so.

Hardness from 6·5 to 7·5.

Specific gravity from 4·208 to 3·157.

Before the blowpipe it fuses easily into a dark-coloured globule.

A great number of analyses (at least 30) of different varieties of garnet have been made, especially by Trollé Wāchtmeister,* Klaproth,† Bucholz, Hisinger,‡ Rothoff,§ and Laugier;‖ but the only conclusion that can be safely drawn from these analyses, is, that garnet is a mixture in various proportions of the three minerals above specified, which having the same primary form, are capable of mixing and of producing crystals, having always the same shape or some modification of it.

Sp. 12. *Essonite.*

Cinnamon stone, kanelstein.

This mineral has been hitherto found only in Ceylon and the United States. It is usually associated with table spar and quartz, and occurs in primary rocks, most commonly gneiss.

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* Kong. Vet. Acad. Handl., 1823, p. 122.

† Beitrage, ii. 16, 22 : v. 168.

‡ Afhandlingar, iv. 385 : ii. 153.

§ Afhandlingar, iii. 324.

‖ Hauy's Mineralogie, ii. 538.

Colour intermediate, between hyacinth red and orange yellow.

It has never been observed in crystals but only in granular masses.

Lustre between vitreous and resinous.

Fracture flat conchoidal; no distinct cleavage perceptible.

Semitransparent to translucent.

Hardness 6·5; specific gravity 3·631.

Captain Lehunt analyzed it several times in my laboratory. The result of his investigations was as follows:

		Atoms.
Silica,	39·826	19·91
Lime,	30·574	8·73
Alumina,	20·141	9·07
Protoxide of iron,	9·459	2·10
	100·000	

The atoms of bases are 19·90, and those of silica 19·91 Hence the mineral consists of simple silicates.

The constituents being the same as in garnet and in the same proportions, it is probable that cinnamon stone is merely a mixture of the three minerals which constitute garnet. If we were to consider it as a peculiar species, it would be

6 atoms silicate of iron,
25 atoms silicate of lime,
26 atoms silicate of alumina;

Or very nearly

1 atom silicate of iron,
4⅙ atoms silicate of lime,
4⅓ atoms silicate of alumina.*

Sp. 13. *Brown Manganese Garnet.*

The locality of this mineral is Franklin, Sussex County, New Jersey. The only specimen which I have seen was sent me by Dr. Torrey from New York.

Colour tombac brown.

Texture granular. The specimen consists of a congeries of imperfect crystals. The crystals have the aspect of four-sided oblique prisms, with angles of about 111° and 69°, terminated by four-sided pyramids.

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* The result of other analyses hitherto made of essonite approaches so

Hardness 6·75.

Brittle, and very easily frangible.

Lustre resinous, glistening.

Opaque, or only translucent on the edges. Specific gravity 3·829.

I found the constituents

		Atoms.
Silica, . .	33·716 .	16·86
Lime, . .	25·884 .	7·39
Alumina, . .	7·972 .	3·54
Protoxide of iron, .	15·840 .	3·52
Protoxide of manganese,	16·704 .	3·71
Water, . .	0·080	
	100·196	

The atoms of the bases are 18·16, while those of silica are only 16·86. This excess makes it possible that one of the bases may be in the state of subsesquisilicate. But if we admit the excess to be accidental, then the mineral will be composed of

2 atoms silicate of lime,
1 atom silicate of alumina,
1 atom silicate of iron,
1 atom silicate of manganese.

It is therefore of a more complicated nature than any of the different garnets hitherto analyzed, and may probably be entitled to rank as a peculiar species.

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near that given in the text, that I did not think it necessary to introduce them. The following table will show the most important of these analyses:

	*	†	‡	§
Silica, ...	38·8	41·87	40·006	41·24
Alumina, ...	21·2	20·57	22·996	24·08
Lime, ...	31·25	33·94	30·573	24·76
Peroxide of iron, . .	6·50	3·93	3·666	7·02
Potash, ...	—	—	0·589	—
Magnesia with Manganese,	—	0·39	trace	0·92
Water, ...	—	—	0·326	0·91
	97·75	100·70	98·156	98·93

[*] Klaproth, Beitrage, v. 138.

[†] Arfvedson, Kong. Vet. Acad. Handl., 1822, p. 87.

[‡] C. G. Gmelin, Edin. Jour. xi. 129.

[§] Nordenskiöld, Bidrag, p. 14.

Sp. 14. *Pyrope.*[*]

Bohemian garnet.

The term *pyrope* was applied by Werner to what had been previously known by the term *Bohemian garnet*, because it occurs in the mountains on the south side of Bohemia, especially Meronitz, Podsedlitz, Chrastian, Trziblitz, and Scheppenthal, where it is imbedded in trap tuff and wacke. A mineral also occurs at Ely, in Fife, in trap tuff, which has been considered as pyrope, though I am not aware that it has ever been subjected either to a rigid mineralogical or chemical examination.

Colour dark blood red, which when held between the eye and the light falls strongly into yellow.

It occurs usually in roundish or angular grains, but it has been found also crystallized; and M. Zippe informs us that M. Moteglek has a regular crystal of it in his museum from the Isergebirge. The primary form is the cube, or at least a right prism with a square base.[†]

No cleavages can be perceived in it.

Fracture conchoidal; streak white.

From transparent to translucent.

Lustre vitreous, slightly inclining to resinous; splendent.

Hardness 7·5; specific gravity 3·78.

It is much more difficultly fusible before the blowpipe than the precious garnet. The bead is black and nearly opaque.

Its constituents, as determined by the analyses of Kobell, and Trollé Wächtmeister, are as follow:

Silica,	42·080	43·70
Alumina,	20·000	22·40
Magnesia,	20·199	5·60
Protoxide of iron,	9·096	11·48
Peroxide of iron,	1·507	—
Protoxide of manganese,	0·320	3·68
Chromic acid,	3·013	7·68
Lime,	1·993	6·72
	98·208[‡]	101·26[§]

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[*] From πυρ, *fire*, and οπτομαι, *I see*. From the peculiar lustre, like *fire*, which it exhibits.

[†] Poggendorf's Annalen, xxvii. 692.

[‡] Kobell, Kastner's Archiv. viii. 447, and ix. 344.

[§] Wächtmeister, Kong. Vet. Acad. Handl., 1825, p. 216.

These two analyses do not correspond. That of Wāchtmeister, being made on the Meronitz pyrope, we have every reason to consider it as exhibiting the constituents of the true pyrope. Now this analysis gives us the following as the atomic proportions of these constituents:

	Atoms.
Silica, . .	21·85
Alumina, . .	9·95
Protoxide of iron, .	2·55
Chromic acid, .	1·18
Lime, . .	1·92
Magnesia, . .	2·24
Protoxide of manganese,	0·81

If we suppose the chromic acid to exist in the mineral in the state of oxide, as is most probable, the atoms of bases will amount to 18·65, while those of the silica are 21·85; so that the atoms of silica exceed those of the bases by 3·23. Hence it is probable that the protoxides of iron and manganese, amounting together to 3·36 atoms are in the state of bisilicates. The atoms of lime, magnesia, and oxide of chromium, approach to half of those of alumina; hence the constitution of pyrope seems to be

10 atoms silicate of alumina,
5 atoms silicates of lime, magnesia, and chromium,
3 atoms bisilicates of iron and manganese.

The magnesia, lime, and oxide of chromium, are to each other nearly as 10, 8, 5; while the oxide of iron to the oxide of manganese nearly as 3 to 1. Hence the formula for pyrope may be

$$10AlS+5(\tfrac{10}{23}Mg+\tfrac{8}{23}Cal+\tfrac{5}{23}\underset{.}{C}hr)S+3(\tfrac{3}{4}\underline{f}+\tfrac{1}{4}\underline{mn})S^2.$$

Sp. 15. *Amphodelite.*[*]

This is a name given by Nordenskiöld to a mineral found by him in the limestone quarry of Lojo, in Finland.

Colour light red.

Its crystalline form resembles that of felspar. It has two cleavages which meet at an angle of 94° 19′. Its fracture resembles that of the scapolite.

Hardness 4·5; specific gravity 2·763. Its constituents, as determined by Nordenskiöld's analysis, are

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[*] Berzelius, Jahresbericht, 1833, p. 174.

		Atoms.
Silica,	45·80	22·9
Alumina,	35·45	15·75
Lime,	10·15	2·9
Magnesia,	5·05	2·02
Protoxide of iron,	1·70	0·37
Water and loss,	1·85	1·64
	100·00	

If we allow for a slight excess of silica, the mineral consists of simple silicates. The formula is

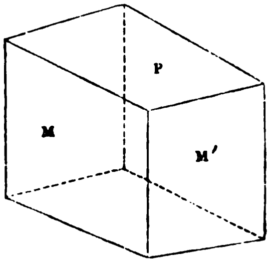
$$3AlS+(\tfrac{11}{21}Cal+\tfrac{8}{21}Mg+\tfrac{2}{21}f)S.$$

Sp. 16. *Zoisite.*

This mineral was discovered by Baron von Zois,* in Carinthia, partly in a granite, in which the zoisite takes the place of felspar, and partly in a quartz rock, where it is associated with cyanite, garnet, and foliated pyroxene. It was analyzed and described by Klaproth in 1807.†

The colour is usually grey; yellowish, greenish, or bluish grey; and sometimes, it is said, brown. It is always light coloured and the tints are not well defined.

It is usually crystallized in oblique prisms, which are rarely perfect, owing to deep longitudinal striæ. According to Mr. Brooke, the primary form is an oblique rhombic prism.



M on M′ 116° 30′

The face P is oblique but not sufficiently distinct for measurement.

Structure foliated. Lustre pearly, shining; translucent.

Hardness 6·25; specific gravity from 3·320 to 3·3207.

Before the blowpipe it swells up and melts on the edges to a yellow glass. With borax swells and fuses into a diaphanous glass. With biphosphate of soda it is decomposed with effervescence, leaving a silica skeleton. With a very small portion of carbonate of soda, it fuses into a slightly greenish glass. With the usual quantity of that flux, gives an intumescent, white, infusible mass.

The following table exhibits the constituents of this mineral, according to the different analyses hitherto made:

---

* Hence the name.

† Beitrage, iv. 179.

	*	†	‡	§	‖
Silica, . . .	45	47·5	40·25	39·300	40·208
Alumina, . .	29	29·5	30·25	29·488	25·588
Lime, . . .	21	17·5	22·50	22·956	23·280
Protoxide of iron, with trace of manganese,	3	4·5	4·50	6·480	7·680
Water, . .	—	0·75	2·00	1·360	1·708
	98	99·75	99·584	99·584	98·464

The result obtained by Bucholz and my first analysis, correspond so closely, that the specimens must have been nearly identical. The mean of the two gives the following atomic proportions of the constituents:

		Atoms.
Silica, . .	19·88 .	3·06
Alumina, . .	13·27 .	2·04
Lime, . .	6·49 .	1
Protoxide of iron, .	1·22 .	0·19
Water, . .	1·48 .	0·22

If we consider the protoxide of iron and the water as only accidental ingredients, it is evident that zoisite is a compound of

2 atoms silicate of alumina,
1 atom silicate of lime.

Its formula is 2 AlS+CalS.

Sp. 17. *Meionite*,¶ or *Scapolite*.**

Paranthine, wernerite, arctizite, bergmannite? chelmsfordite? micarelle rapidolite, spreustein? dipyre.

The different varieties of minerals belonging to this species were discovered at different times; and having but little apparent resemblance to each other, were naturally distinguished by different names. It was only by careful crystallographical examinations and chemical analyses that their identity was made out. *Meionite* is described by Romé de Lisle, and was constituted into a particular species, and named by Hauy. *Wernerite*, or foliated scapolite, was discovered and described by Andrada, and named by him in honour of Werner. *Paranthine*, or radiated scapolite, was first observed at Arendal, in Norway, and was named by Werner from the rod like appearance of the crystals.

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* Klaproth, Beitrage, iv. 179. The specimen from Carinthia.

† Klaproth, ibid. p. 183. From the same locality, but of a yellowish brown colour, and having a specific gravity of 3·265.

‡ Bucholz, Gehlen's Jour. (2d series), i. 197. Locality not specified.

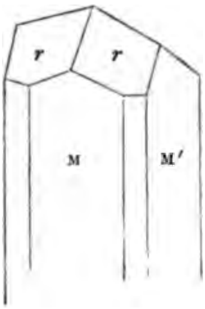
§ By my analysis. Specimen from Carinthia.

‖ By my analysis. Specimen from Williamsburgh, Massachusetts. Specific gravity 3·2707.

¶ From *μειων*, *less;* so named from the lowness of the pyramid with which the crystal is usually terminated.

** This name was imposed by D'Andrada, from the rodlike appearance of the crystals.

This species, when pure, has a white, or greyish-white colour, which is the colour of *meionite*. Frequently there is a shade of green or yellow superadded to the white. This is the case with the varieties arranged under the name of *scapolite*. Frequently the colour is red, or brownish, or yellowish red, doubtless from the admixture of foreign matter. The green colour seems owing to an admixture of augite, the red to an admixture of peroxide of iron. Streak greyish white.



It occurs occasionally massive, but much more frequently crystallized. The primary form obtained by cleavage is a right square prism. Most commonly the prism is terminated by a low four-sided pyramid, the faces of which, *r*, *r*, are inclined to each other at an angle of 136° 22′, and *r* on M 112° 5′. The lateral edges of the prism are most frequently replaced by one, two, or even three small planes, making the prism eight, twelve, or sixteen-sided. The edges of the terminating pyramid are also often replaced by tangent planes. Sometimes the pyramid is incomplete, leaving a small portion of the primary terminal face of the prism at its apex.

Surface of the prism often streaked longitudinally.

Structure foliated; fracture imperfect conchoidal, or uneven; lustre vitreous.

From transparent to translucent on the edges; brittle.

Hardness 4·25; specific gravity of meionite from 2·612 to 2·650; of scapolite from 2·709 to 2·749.

Before the blowpipe it froths and melts into an enamel or glass, white, except when the colour is altered by the presence of foreign matter.

The following table exhibits the constituents of this mineral according to the best analyses hitherto made of it:

	*	†	‡	§	‖	¶	**	**
Silica, . .	40·8	40·531	39·915	43.83	41·25	45	45·348	46·300
Alumina, . .	30·6	32·726	31·970	35·43	33·58	33	31·672	26·484
Lime, . .	22·1	24·245	23·856	15·96	20·36	17·6	23·952	18·624
Soda with lithia,	2·4	—	—	—	—	1·5	—	3·640
Potash with soda,	—	1·812	0·894	—	—	0·5	—	—
Peroxide of iron,	1	0·182	2·242	—	—	1	—	—
Protox. of mangan.,	—	—	0·174	—	0·54	—	—	—
Water, . .	—	—	0·949	1·03	3.32	—	—	5·040
Carb. acid & loss,	3·1	—	—	—	—	—	—	—
	100	99·496	100	99·28	99·05	98·6	100·972	100·088

It is obvious, from a bare inspection of this table, that the only essential constituents of this mineral are silica, alumina, and lime. A mean of all the analyses gives us for these constituents the following quantities:

		Atoms.
Silica, .	42·871 .	21·43
Alumina, .	31·933 .	14·19
Lime, . .	20·837 .	5·95

The mean gives the proportion of lime too low, and that of alumina too high, owing to the fourth and sixth analyses, which do not well accord with the rest. If we leave them out we shall find the atoms of the bases equal to those of silica, and the atoms of alumina twice as great as those of lime. Hence the constitution of this mineral is

2 atoms silicate of alumina,
1 atom silicate of lime.

And the formula $2AlS+CalS$.

Thus the chemical constitution of zoisite and scapolite is the same. Yet they differ in their specific gravity, zoisite being 3·327, and scapolite 2·740. Zoisite is also harder, being 6·25, while that of scapolite is 4·25. The shape of the crystals is also different, zoisite being an oblique rhombic prism, while that of scapolite is a square prism. These differences makes it requisite, notwithstanding their identity in composition, to constitute them different species. They stand in the same relation to each other that arragonite does to calcareous spar.[*]

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* A meionite from Vesuvius. Leopold Gmelin, Schweigger's Jour. xxv. 38.

† A meionite from Monte Somma. Stromeyer, Untersuchungen, p. 378.

‡ A meionite from the Tyrol. Ibid.

§ A scapolite from Finland, white with a shade of green. Nordenskiöld, Bidrag, p. 58.

‖ A white scapolite, with a shade of yellow, from Finland. Nordenskiöld, Ibid.

¶ A scapolite; Laugier, Ann. de Mus. d'Hist. Nat. x. 472.

** By my analysis. Two scapolites from the United States. The first had a specific gravity of 2·717; the second, from Bolton, Mussachusetts, had a specific gravity of 2·709.

Sp. 18. *Prehnite.*

Koupholite, yu.

This mineral was constituted into a peculiar species by Werner, from specimens brought from the Cape of Good Hope, by Colonel Prehn, about the year 1780. It occurs in veins in primary rocks, and also in trap rocks, both in veins and in amygdaloidal cavities.

Colour sometimes white, but most commonly green of

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[*] The mineral analyzed by Ekeberg (Afhandlingar, ii. 144), and called by him *natrolite*, is generally considered as a variety of scapolite.

Its colour is light greenish-grey; lustre glistening and waxy; structure imperfect foliated; translucent; hardness about 5; tough; specific gravity 2·723. Before the blowpipe it melts per se into a transparent-green glass. Its constituents, by my analysis, are,

		Atoms.
Silica,	43·572	21·78
Alumina,	24·480	10·88
Lime,	15·460	4·41
Peroxide of iron,	5·540	1·11
Soda,	9·148	2·28
Water,	1·800	
	100	

The atoms of silica exceed those of the bases by 4·1.

The constituents seem to be

11 atoms silicate of alumina,
5 atoms silicate of lime,
2 atoms bisilicate of soda,
1 atom bisilicate of iron.

If the bisilicates of soda and iron were accidental, then the natrolite would agree with scapolite in its composition.

At Grenville, in Lower Canada, in an aggregate of table spar, sphene, graphite, &c., there occurs a brown-coloured mineral in small grains, which looks like scapolite. Its specific gravity is 2·7449, and its constituents

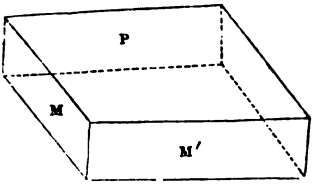
		Atoms.
Silica,	52·85	5·21
Alumina,	24·70	2·16
Lime,	17·75	1
Water,	3·40	
	98·70	

This is $2AlS^2 + CalS$.

It differs from scapolite in containing an additional atom of silica, but the grains were so small that it was difficult to be sure that all the table spar in which they were imbedded was excluded.

various shades, as apple-green, leek-green, sisken-green, &c. Streak white.

It occurs both granular and fibrous. Frequently amorphous, or in various derivative shapes. But it is also crystallized, and the primary form of the crystal is a right rhomboidal prism.



M on M' 100°.

The face P is usually replaced by two low faces making an angle of 91° 30'. The lateral edges of the prism are frequently replaced by tangent planes.

Lustre vitreous, except that of face P, which is pearly, at least when produced by cleavage.

Semitransparent to translucent on the edges.

Hardness 5; specific gravity from 2·90 to 2·953.

Before the blowpipe it froths and melts into a slag of a light green colour.

When heated it becomes electric.

Does not gelatinize with acids.

The constituents of this mineral, according to the best analyses hitherto made are as follow:

	*	†	‡	‡	§	§	‖
Silica, ...	43·80	42·5	42·875	43·00	43 60	42·22	43·048
Alumina, . . .	30·33	28·5	21·500	23·25	23 00	23·68	23·840
Lime, ...	18·33	18·4	26·500	26·00	22·33	23·52	26·164
Protoxide of iron, .	5·66	3·0	3·000	2·00	2·00	3·06	0·640
Prot. of manganese, .	—	—	0·250	0·25	—	—	0·416
Potash and soda, . .	—	0·75	—	—	—	—	1·028
Water, . . .	1·16	2·00	4·625	4·00	6·40	5·58	4·600
	99·28	95·15	98·75	98·5	97·33	98·06	99·772

The mean of these analyses gives us

			Atoms.
Silica, . .	43	.	21·5
Alumina, . .	24·97	.	11·09
Lime, . .	23·03	.	6·58
Protoxide of iron,	2·78	.	0·61
Water, . .	4·05	.	3·6

---

* Klaproth; Ann. de Chim. i. 208. It was a foliated prehnite.

† Laugier, ibid. lxxv. 78. A fibrous prehnite.

‡ Gehlen; Schweigger's Jour. iii. 182. Both fibrous prehnites.

§ By my analyses. The first specimen was light green, the second white; both fibrous, and from the neighbourhood of Glasgow.

‖ A white prehnite from the Castle Hill of Edinburgh, analyzed by Captain Lehunt. Known in Edinburgh by the name of *Wollastonite*.

The atoms of silica exceed those of the bases by 3·22. Hence the lime must be in the state of sesquisilicate.

Probably the lime from the mean exceeds the true quantity, in consequence of the uncommon quantity obtained by Gehlen and Lehunt in their analyses. I am disposed, therefore, (uniting the protoxide of iron to the alumina,) to consider the constitution of prehnite to be

2 atoms silicate of alumina,
1 atom sesquisilicate of lime,
½ atom water.

The oxide of iron is never wanting altogether, but it varies so much in its quantity that it can scarcely be considered as an essential constituent.

Sp. 19. *Anhydrous Scolezite.*[*]

This mineral occurs in the large masses of scapolite at Ersby, in Finland. It was taken for scapolite till the analysis of Nordenskiöld ascertained its true nature, and induced him to constitute it a peculiar species.

Colour white.

Occurs in crystals, but the shape is not mentioned by Nordenskiöld; only one cleavage perceptible.

Translucent.

Fracture small conchoidal.

Lustre vitreous; hardness 6; difficultly fusible.

Before the blowpipe behaves like common scolezite, only it requires more heat to be fused into a glass with soda.

The specific gravity not determined.

The constituents of this mineral, according to the analysis of Nordenskiöld, are as follow:

		Atoms.
Silica, .	54·13 .	27·06
Alumina,	29·23 .	12·99
Lime, .	15·46 .	4·41
Water, .	1·07 .	0·95
	99·89[†]	

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[*] From *σκωληξ, a worm*. From the appearance which scolezite assumes under the blowpipe.

[†] Bidrag, p. 67.

These constituents are obviously

3 atoms silicate of alumina,
1 atom tersilicate of lime.

The water is doubtless accidental, being too small in quantity to constitute an atomic proportion.

Sp. 20. *Iolite.*[*]

Cordierite, dichroite, peliom, steinheilite, sapphire d'eau.

This mineral was first observed at Capo de Gate, and called *iolite*, from its blue colour, and *dichroite*, from the two colours which it frequently displays, when viewed in two different positions. The variety called *pelium*, or *peliom* (from its blue colour), was first found at Bodenmais, in Bavaria, while *steinhelite* was discovered in the copper mine of Orrijarvi, in Finland. It was the analysis of Stromeyer that demonstrated the identity of dichroite and steinheilite.

Colour various shades of blue, generally inclining to black; streak white.

It occurs generally massive, but is sometimes crystallized. The primary crystal is a regular six-sided prism, most commonly having the lateral edges replaced by tangent planes. The terminal edges are also frequently replaced by planes making angles of 137° 46′ (according to Mr. W. Phillips), with the corresponding lateral faces of the prism.

Fracture conchoidal; lustre vitreous.

Translucent; sometimes transparent. When we view the crystal in the direction of the axis of the prism the colour is blue, but when we look through it in a direction perpendicular to the axis it has a yellowish-grey colour.

Hardness 7; specific gravity from 2·5969 to 2·6643. A Greenland specimen was found by Stromeyer, 2·5969, steinheilite, 2·6003. I found the specific gravity of a fine transparent specimen from Connecticut, in plates, to vary from 2·651 to 2·6643. It was not absolutely free from some very thin plates of mica, which became visible when the specimen was ignited.

When strongly heated before the blowpipe the edges melt with difficulty into a glass equalling the original mineral in colour and transparency.

The constituents of this mineral are as follow:

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[*] From *ιον, a violet*, and *λιθος, a stone.* So called on account of its colour.

	*	†	‡	§	‖	¶
Silica, . . .	43·6	49·170	48·352	48·538	48·525	49·620
Alumina, . . .	37·6	31·106	31·706	31·730	31·502	28·720
Magnesia, . . .	9·7	11·454	10·157	11·305	15·000	8·640
Lime, . . .	3·1	—	—	—	—	0·228
Protoxide of iron, .	4·5	6·338	8·316	5·686	1·610	11·580
Protoxide of manganese,	trace	0·037	0·332	0·702	0·243	1·508
Potash ? . . .	1·0	—	—	—	—	—
Water, . . .	—	1·204	0·595	1·687	1·705	—
	99·5	99·309	99·458	99·648	98·585	100·296

The mean of these analyses (leaving out the first as differing too much from the others), gives us the following numbers:

		Atoms.
Silica, . . .	48·841 .	24·42
Alumina, . .	31·35 .	13·93
Magnesia, . .	11·31 .	4·52
Protoxide of iron, .	6·306 .	1·40
Protoxide of manganese,	0·564 .	0·12

The atoms of bases are 19·97, while those of silica are 24·42 Thus there is an excess of 4·45 atoms of silica, which corresponds with the atoms of magnesia. We may infer from this that the magnesia is in the state of bisilicate. If we include the manganese along with the iron, we have the ratio of the bases nearly, oxide of iron 1, magnesia 3, alumina 9. Hence the constitution of iolite seems to be

9 atoms silicate of alumina,
3 atoms bisilicate of magnesia,
1 atom silicate of iron.

The formula is $9\text{AlS}+3\text{MgS}^2+\text{fS}$.

Sp. 21. *Hydrous Iolite.*

This mineral occurs in red granite, in the neighbourhood of Abo, accompanied by a light bluish-grey dichroite. It was first described and analyzed in 1827, by M. Bonsdorf.[*]

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* Leopold Gmelin, Hoffman's Mineralogie, iv. 2, 119. The specimen *peliom.*

† Stromeyer, Untersuchungen, p. 329. The specimen was from Greenland.

‡ Stromeyer, ibid. Specimen from Bodenmais, and consequently peliom.

§ Stromeyer, ibid. The specimen was a steinheilite.

‖ By my analysis. The specimen was steinheilite.

¶ By my analysis. The specimen was in the state of very beautifu transparent blue plates from Connecticut.

The colour is greenish-brown, or dark olive-green. When viewed by transmitted light, thin plates of a light-green colour are seen.

It occurs crystallized in six-sided irregular prisms. The lateral edges are usually replaced by so many faces that the prism appears nearly cylindrical.

Structure straight foliated, folia perpendicular to the axis of the prism; cross fracture conchoidal.

Lustre of the fracture talcy, of the surface of the plates waxy.

Hardness 3·75; specific gravity not specified.

When heated in a glass tube it gives out pure water, but undergoes no farther alteration. It cannot be fused by the blowpipe per se.

Its constituents, according to the analysis of Bonsdorf, are as follow:

		Atoms.
Silica, . .	45·05 .	22·52
Alumina, .	30·05 .	13·35
Magnesia, .	9·00 .	3·60
Protoxide of iron,	5·30 .	1·17
Water, . .	10·60 .	9·42
	100·00	

Here the atoms of base exceed those of silica by 4·4, which rather exceeds the atoms of magnesia. The constituents are,

10½ atoms silicate of alumina,
3 atoms bisilicate of magnesia,
1 atom silicate of iron,
8 atoms water.

Or, taking the oxide of iron along with the magnesia,

3 atoms silicate of alumina,
1 atom bisilicates of magnesia and iron,
2 atoms water.

The fomula will be $3AlS+1(\frac{3}{4}Mg+\frac{1}{4}f)S^2+2Aq$.

It is very nearly an atom of iolite united to two atoms water.

Sp. 22. *Staurotide.*[*]

Grenatite, staurolite.

This mineral occurs in primary rocks, particularly in mica slate. St. Gothard, the Tyrol, St. Jago de Compostella, and Oporto, are some of the best known localities. It is met with also in Aberdeenshire, and in the United States.

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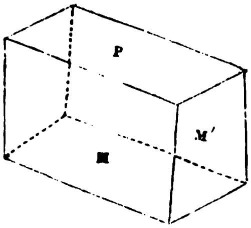
[*] Kong. Vet. Acad. Handl., 1827, p. 157.

[†] From *σταυροειδης, like a cross.* So called from the cruciform appearance of its twin crystals.



Colour dark reddish brown; streak white.

It is always crystallized, and the primary form is a right rhombic prism.

M on M' 129° 20'

The acute edges of the prism are commonly replaced by tangent planes, making angles with the adjacent planes of the prism of 115° 20'. The obtuse solid angles of the prism are frequently replaced by a triangular plane, making with M or M' an angle of 137° 58'. Two of these crystals frequently cross each other either at right angles or obliquely. Hence the name, and the veneration with which they were formerly regarded in Catholic countries.

Fracture conchoidal or uneven.

Lustre vitreous, inclining to resinous.

Translucent, frequently only on the edges.

Hardness 6·75; specific gravity of the opaque and impure specimens, 3·273; that of a pure specimen I found 3·693.

Before the blowpipe it assumes a dark colour, but does not melt.

The following table exhibits the constituents of staurotide, according to the best analyses:

	*	†	‡	§
Silica,	37·5	27	50·076	36·696
Alumina,	41·0	52·25	35·900	39·880
Protoxide of iron,	15·25	18·5	13·908	18·144
Protoxide of manganese,	0·5	0·25	—	4·046
Magnesia,	0·5	—	trace	0·686
Moisture,	—	—	1·200	0·080
	97·75	98	101·084	99·550

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* Klaproth, Beitrage, v. 80. A dark brownish staurotide from St. Gothard, specific gravity 3·510.

† Klaproth, ibid. A brownish red variety from the same place, having a specific gravity of 3·765.

‡ By my analysis. The crystal was a cross nearly opaque, and having a specific gravity of 3·273.

§ By my analysis. The specimen was pure, and had a specific gravity of 3·693.

If we take the last of my analyses, which from its purity I consider as very nearly correct, as exhibiting the true constitution of staurotide, it will consist of

	Atoms.
Silica, . .	18·40
Alumina, . .	17·72
Protoxide of iron, .	4·03
Protoxide of manganese,	0·90

The atoms of base are 22·65, exceeding those of silica by 4·25 atoms, nearly the amount of the atoms of oxides of iron and manganese. If we unite the oxide of manganese to that of iron, the mineral will be a compound of

4 atoms silicate of alumina,
1 atom hexasilicate of iron.

The first analysis of Klaproth gives very nearly the same result. In my first analysis the mineral obviously contained an excess of silica, while in Klaproth's second there was too little. The mean of the two would approach pretty near the truth.

Sp. 23. *Gehlenite.*[*]

Stylobite.

This mineral was found on Mount Monzoni, in the valley of Fassa in the Tyrol. It was brought to Munich during the course of the year 1815, by the mineral dealer Frischholtz, and was soon after described and analyzed by Professor Fuchs.

Colour different shades of grey, none of them bright.

It is always crystallized in rectangular prisms, with square bases, but whether the primary form be a cube, or a right square prism, has not been determined.

Fracture uneven, passing into splintery.

Lustre resinous, inclining to vitreous.

Usually opaque; sometimes faintly translucent on the edges; brittle.

Hardness 6·5; specific gravity from 2·9166 to 3·029.

Before the blowpipe fuses with difficulty, and only when in thin splinters. It dissolves slowly when mixed with borax. Gelatinizes when heated in muriatic acid; even dilute muriatic acid acts upon it without the application of heat.

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[*] Named in honour of the German chemist, M. Gehlen.

Its constituents are as follow:

Silica, . .	29·64 .	29·132
Alumina, .	24·80 .	25·048
Lime, . .	35·30 .	37·380
Protoxide of iron,	6·56 .	4·350
Water, . .	3·30 .	4·540
	99·60*	100·450†

These two analyses approach each other very closely. The mean of both gives us

		Atoms.
Silica, . .	29·386 .	14·69
Alumina, .	24·924 .	11·07
Lime, . .	36·340 .	10·38
Protoxide of iron,	5·455 .	1·20
Water, . .	3·920 .	3·48

The atoms of bases amount to 22·65 exceeding those of silica by 7·96, or nearly one-third of the bases. Hence an atom and a half of bases must be combined with every atom of silica. If we unite the oxide of iron to the lime, the atoms of alumina and lime are nearly equal. Hence Gehlenite seems composed of

3 atoms subsesquisilicate of alumina,
3 atoms subsesquisilicates of lime and iron,
1 atom water.

The formula will be $3\text{Al}^{1\frac{1}{2}}\text{S}+3(\frac{8}{9}\text{Cal}+\frac{1}{9}\text{f})^{1\frac{1}{2}}\text{S}+\text{Aq}$.

Sp. 24. *Weissite.*‡

This mineral was observed in Erik Matt's mine at Fahlun. It was described and analyzed by Trollé Wächtmeister, in 1827.§

Weissite occurs thinly scattered in a chlorite slate in kidney-shaped pieces about the size of a hazel nut.

Colour ash grey, slightly inclining to brown, sometimes covered with a blackish ochre.

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* Fuchs, Schweigger's Jour. xv. 377.

† By my analysis. The specimen was digested in acetic acid to remove any adhering lime.

‡ Named by Trollé Wächtmeister, to whom we owe the knowledge of this mineral, in honour of Professor Weiss, of Berlin. See Poggendorf's Annalen, xiv. 190.

§ Kong. Vet. Acad. Handl., 1827, p. 80.

The largest pieces show no regular texture, but give an even and coarse-grained fracture. In some smaller pieces the texture is foliated, and there are indications of a rhomboidal prismatic texture.

Powder pure white; by ignition acquires a slight shade of red.

Scratches glass, but is scratched by steel.

Lustre between pearly and waxy.

Scarcely translucent.

Specific gravity 2·808.

Before the blowpipe becomes pure white, and fuses on the edges. On charcoal gives out a zinc smoke. Heated in a tube it gives out water which at first reddens litmus paper, and finally renders it blue. With borax it fuses slowly into a colourless glass. With biphosphate of soda it behaves in the same way, leaving a silica skeleton. With carbonate of soda it fuses slowly into an opaque slag, which finally melts into a bead.

Its constituents, as determined by Trollé Wāchtmeister, are as follow:

		Atoms.
Silica,	59·69	29·84
Alumina,	21·70	9·64
Magnesia,	8·99	3·60
Protoxide of iron,	1·43	0·31
Protoxide of manganese,	0·63	0·14
Potash,	4·10	0·68
Soda,	0·68	0·17
Oxide of zinc,	0·30	0·05
Water with a little ammonia,	3·20	2·84
	100·72	

The atoms of silica are very nearly double those of the bases. Hence the mineral is composed of bisilicates. While those of the alumina are very nearly double those of all the the other bases.

We may therefore consider weissite as composed of

2 atoms bisilicate of alumina,

1 atom bisilicate of magnesia, iron, manganese, potash, soda, and zinc,

½ atom water.

If we unite the oxides of iron and manganese, and the potash and soda, then the ratio of the atoms of magnesia, potash, and iron, will be to each other as the numbers 8, 2, and 1. Hence the formula for the constitution of weissite will be $2AlS^2+1(\frac{8}{11}Mg+\frac{2}{11}K+\frac{1}{11}f)S^2+\frac{1}{2}Aq$.

Whether the water was a chemical constituent of the mineral or not must remain doubtful.

Sp. 25. *Fahlunite, Triclasite?*

This mineral occurs at Fahlun, particularly in Erik Matt's mine in chlorite slate. The descriptions of it by Hauy, Hisinger, &c., and the specimens sent me from Sweden differ so much from each other that there is reason to believe that various minerals have been confounded together under the same name. On that account I shall confine myself to the description and analyses given by Trollé Wachtmeister, as from his situation he had the best opportunity of determining the characters of the true fahlunite.

The colour is sometimes coal black, sometimes greyish brown, or blackish brown, and in thin splinters light brown; streak white; powder light grey; when heated to redness it becomes fawn coloured.

The specimens found in the chlorite slate in Erik Matt's mine are always amorphous; but in the Terra Nova shaft at Fahlun, and in the Lovise mine in the same place it is found in crystals, and from the examination of these crystals by Mitcherlich it appears that they have exactly the form of topaz crystals.

Fracture even, passing into fine splintery.

Lustre waxy, but inconsiderable.

Easily scratched by steel.

Specific gravity from 2·62 to 2·79.

Before the blowpipe in thin splinters it becomes white, and fuses on the edges with some effervescence into a glass. With the usual fluxes it gives a glass with a light iron colour. When heated in a glass tube it gives out water.

Its constituents, determined by Trollé Wachtmeister, are as follow:—

	*	†	‡	§
Silica, . . .	43·51	44·60	44·95	51·840
Alumina, . .	25·81	30·10	30·70	24·780
Protoxide of iron, .	6·35	3·86	7·22	10·296
Magnesia, . .	6·53	6·75	6·04	7·704
Protoxide of manganese,	1·72	2·24	1·90	2·248
Soda, . . .	4·45	1·98	—	—
Potash, . . .	0·94		1·38	—
Fluosilicic acid, . .	0·16	—	—	—
Lime, . . .	trace	1·35	0·95	2·684
Water, . . .	11·66	9·35	8·65	0·576
	101·13	100·23	101·79	100·128

The three analyses of Trollé Wachtmeister agree very closely with each other. The mean of them is as follows:—

		Atoms.
Silica, . .	44·35 .	22·17
Alumina, . .	28·71 .	12·76
Magnesia, . .	6·44 .	2·57
Protoxide of iron, .	5·81 .	1·29
Protoxide of manganese,	1·95 .	0·43
Soda, . .	1·48 .	0·37
Potash, . .	1·76 .	0·29
Lime, . .	0·76 .	0·21
Water, . .	9·88 .	8·78

The atoms of the bases being only 17·94, while those of silica are 22·17, it is evident that some of these bases must be in the state of bisilicates. Now the surplus in the silica being 4·23 atoms, and the atoms of magnesia, protoxide of iron, and oxide of manganese being 4·29, it is probable that these last are in the state of bisilicates. The potash, soda and lime amount to the fifth of the atoms of magnesia, iron and manganese, while the atoms of alumina are thrice those of these last. Hence the constitution of fahlunite seems to be

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* Trollé Wachtmeister, Kong. Vet. Acad. Handl., 1827, p. 21. The specimen was from Erik Matt's mine, and not crystallized. Sp. gr. 2·68.

† Ibid. p. 25. From Terra Nova, and in regular crystals. Sp. gr. 2·74.

‡ Ibid. p. 27. From Lovise mine. Crystallized. Sp. gr. 2·79.

§ A specimen analyzed by me. Its colour was yellowish brown, and its specific gravity 2·632. In other respects it agreed with the description in the text. The remarkable difference was the absence of water. It was an *anhydrous fahlunite.*

15 atoms silicate of alumina,
5 atoms bisilicate of magnesia, iron, and manganese,
1 atom silicate of potash, soda, and lime,
10 atoms water.

Or if the silicates of potash, soda, and lime, (which vary very much in the different specimens,) were considered as only accidental, then the constitution would be

3 atoms silicate of alumina,
1 atom bisilicate of magnesia, iron, and manganese,
2 atoms water.

The formula is $3\mathrm{AlS}+(\frac{6}{10}\mathrm{Mg}+\frac{3}{10}\mathrm{f}+\frac{1}{10}\mathrm{mn})\mathrm{S}^2+2\mathrm{Aq}$.

The constitution of anhydrous fahlunite deduced from the last analysis in the table, is

15 atoms silicate of alumina,
5 atoms bisilicate of iron,
4 atoms bisilicate of magnesia,
1 atom bisilicate of lime.

Or uniting the magnesia and lime,

3 atoms silicate of alumina,
1 atom bisilicate of iron,
1 atom bisilicate of magnesia and lime.

The formula is $3\mathrm{AlS}+\mathrm{fS}^2+(\frac{4}{5}\mathrm{Mg}+\frac{1}{5}\mathrm{Cal})\mathrm{S}^2$.

So that it differs in other respects from hydrous fahlunite, as it contains more silica.

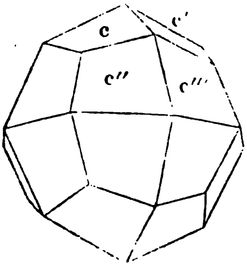
Sp. 26. *Leucite.**

Amphigene, vesuvian, white garnet.

This mineral occurs in imbedded crystals in lava. The lavas of Vesuvius, and the basalts of Italy and Bohemia, abound with it. The road from Rome to Frascati is in many places covered with it.

Colour reddish, yellowish, or greyish white; also ash grey and smoke grey; streak white.

Always crystallized in crystals approaching to a sphere, and consisting of twenty-four trapezoidal faces.



c on c′ 131° 48′ 16″

$$\left.\begin{array}{c}\text{c on c}''\\ \text{or}\\ \text{c}'\text{ on c}'''\end{array}\right\}\ 146^\circ\ 26'\ 33''$$

These crystals exhibit joints parallel to the faces of a rhomboidal dodecahedron, and to those of the cube.

---

* *From λευκος, white;* on [illegible] its white colour.

The cube being the simplest of the two has been chosen for the primary form of the crystal. The leucite crystal is formed by each of the angles of the cube being replaced by three planes, which planes by enlargement have enveloped and concealed the primary faces of the cube.

Fracture conchoidal; surface of the crystals sometimes even, but rough for the most part.

Lustre vitreous; from semitransparent to translucent; brittle.

Hardness 7; specific gravity 2·490.

Infusible before the blowpipe per se. It fuses with borax or with carbonate of lime, though with difficulty into a clear globule.

Its powder changes the blue tincture of violets to green.

The following table exhibits the constituents of leucite, according to the best analysis hitherto made:

	*	†	†
Silica,	53·750	58·70	56·10
Alumina,	24·625	19·95	23·10
Potash,	21·350	21·40	21·15
Lime,	—	1·35	—
Peroxide of iron,	—	0·40	0·95
	99·725	101·80	101·3

The mean of these three analyses gives us

		Atoms.
Silica,	56·18	28·09
Alumina,	22·56	10·02
Potash,	21·30	3·55

This approaches pretty nearly to

3 atoms bisilicate of alumina,
1 atom bisilicate of potash.

The formula is $3AlS^2+KS^2$.

Sp. 27. *Pipestone.*

I give this name to a mineral from North America, of which the Indians make their tobacco pipes. I got the specimen in my possession from my friend and old pupil, Dr. Scouler; who spent a summer on the north west coast of America, between Nootka Sound and the Columbia river, and among many other natural productions of the country, he brought home a specimen of this pipestone, which he was good enough to put in my possession. It had been given him by the natives, and he was able to learn nothing about the part of the country from which it came, nor of the nature of the rocks with which it is associated.

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* Klaproth, Beitrage, ii. 42.

† Arfvedson, Afhandlingar, vi. 255. Arfvedson by inadvertance, has given the name of *meionite* to one of the leucites analyzed by him.

It constitutes a compact stone through which a few scales are scattered, having some resemblance to *claystone*, but being much softer; fracture earthy.

Colour light greyish blue; powder light blue; sectile; dull; opaque.

Hardness 1·5; specific gravity in different trials, varied from 2·606 to 2·608.

The particles when scraped off with a knife feel gritty between the teeth.

Infusible before the blowpipe.

I made two analyses of it, the result of which was as follows:

Silica,	55·620	56·60
Alumina,	17·208	17·42
Soda,	12·160	12·80
Peroxide of iron,	7·612	6·308
Lime,	2·256	2·076
Magnesia,	0·112	0·292
Water,	4·600	4·566
	99·568	100·062

The mean of these gives us

		Atoms.
Silica,	56·11	28·05
Alumina,	17·314	7·69
Soda,	12·48	3·12
Peroxide of iron,	6·960	1·39
Lime,	2·166	0·61
Magnesia,	0·202	0·08
Water,	4·583	4·07

These numbers approach very nearly

6 atoms bisilicate of alumina,
3 atoms bisilicates of soda, lime, and magnesia,
1 atom quatersilicate of iron,
3 atoms water.

Or if the quatersilicate of iron be considered as accidental, the constitution will be

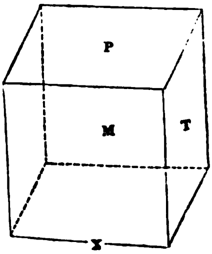
2 atoms bisilicate of alumina,
1 atom bisilicate of soda, lime, and magnesia,
1 atom water.

The formula is $2AlS^2+(\frac{40}{49}N+\frac{8}{49}Cal+\frac{1}{49}Mg)S^2+Aq$.

Sp. 28. *Murchisonite.*

This mineral was discovered by Mr. Levy, interspersed in small crystals in the conglomerate belonging to the new red sandstone, from the neighbourhood of Dawlish and Heavitree, near Exeter.*

The colour of this mineral is not given, but one of the cleavage faces has a pearly lustre, and the mineral presents a golden yellow reflection, generally not uniform but in spots. By cleavage a four-sided prism is obtained of the following dimensions;



P on T 90°, P on M 106° 50′, M on T 90.

Sometimes the edge X is replaced by a plane, making an angle with P′ of about 120°.

Texture foliated. In thin laminæ, transparent.

Hardness the same as felspar, or 6.

Specific gravity, as determined by Mr. Kent, 2·5091.

Its constituents, according to the analysis of Mr. R. Phillips, are

		Atoms.	
Silica, .	68·6 .	34·3 .	14·11
Alumina, .	16·6 .	7·37 .	3·03
Potash, .	14·8 .	2·43 .	1
	100·0		

This corresponds with

3 atoms tersesquisilicate of alumina,
1 atom tersesquisilicate of potash.

The formula will be $3AlS^{3\frac{1}{2}}+KS^{3\frac{1}{2}}$.

Sp. 29. *Gabronite.*†

Compact scapolite.

This mineral has been found only in a vein of titaniferous iron near Arendal in Norway.

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* Phil. Magazine (2d series), i. 448.

† Phillips' Mineralogy, p. 139.

It is of a bluish or greenish grey colour; also reddish, and red. The bluish variety is found near Arendal along with hornblende; the greenish and red variety at Fredericksvarn, disseminated in a large grained syenite.

Its structure is foliated, being mechanically divisible, though with difficulty parallel to the sides of a rectangular prism.

Translucent on the edges and hard enough to scratch glass, though not to give fire with steel. Specific gravity nearly 3.

Before the blowpipe it fuses with difficulty into an opaque white globule.

Its constitution, according to the analysis of John, are as follow:

		Atoms.
Silica,	54	27
Alumina,	24	10·66
Magnesia,	1·5	0·6
Potash and soda,	17·25	3·45
Protox. of iron and mangan.,	1·25	0·27
Water,	2	1·77
	100	

This corresponds very nearly with

3 atoms bisilicate of alumina,
1 atom bisilicate of potash and soda.

The formula will be $3AlS^2+K,NS^2$.

Sp. 30. *Icespar.*

This mineral occurs at Monte Somma, near Naples, in lava, where it is much mixed with meionite and nepheline.

Colour greyish white, inclining sometimes to yellowish white.

Often massive; sometimes crystallized in thin longish six-sided tables. Primary form a right oblique four-sided prism, the faces of which are inclined at an angle of 129° 40′. The edges of this prism are usually replaced by one or two planes. The angles also are occasionally replaced by tangent planes. Lateral planes longitudinally streaked.

Lustre shining, vitreous; fracture imperfect foliated; strongly translucent; crystals transparent; very easily frangible; specific gravity 2·4365; hardness about 3.

Before the blowpipe on charcoal it becomes vitreous, semitransparent, and white, and fuses with difficulty on the edge into a blebby semitransparent glass; with borax fuses into a diaphanous glass.

Its constituents are

Silica, . . .	63·56
Alumina, . .	24·06
Potash, . . .	10·03
Lime, . . .	0·94
Peroxide of iron, .	0·92
Water, . . .	0·37
Oxide of manganese,	trace
	99·88

This is equivalent to $6AlS^{2\frac{1}{4}}+KS^{2\frac{1}{4}}$.

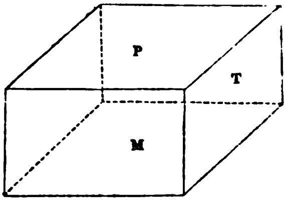
Sp. 31. *Felspar.*

Amausite, amazonstone, adularia, felstein, fusible hornstone, lemanite, lodulite, moonstone, napoleonite, necronite, orthose, fusible petrosilex, sunadin.

This mineral was long confounded with *albite*, from which it was first distinguished by chemical analysis. Being one of the constituents of granite it is a very common mineral. For the first accurate description of it, we are indebted to Mr. Henry Rose.

Colour white or grey; often flesh red; sometimes green; streak greyish white.

Sometimes massive, but most frequently crystallized. The primary form is a doubly oblique prism.



P on M 90°
P on T 67° 15′
M on T 120° 35′

According to the measurement of Mr. W. Phillips. For a description of the crystalline forms, we refer the reader to the Memoir of M. Gustavus Rose,* and to Phillips' Mineralogy.†

Structure foliated; fracture conchoidal; lustre vitreous; transparent to translucent on the edges; hardness 6; brittle.

The specific gravity of seven different specimens was determined by M. H. Rose. The green variety called amazon stone, was the heaviest, being 2·581; the lightest was from Baveno, being 2·394. That of the other specimens was 2·569, 2·574, 2·395, 2·468, and 2·496.‡

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* Ann. de Chim. et de Phys. xxiv. 5. † P. 114.
‡ Ann. de Chim. et de Phys. xxiv. 14.

Before the blowpipe it fuses with difficulty, and only on the edges. With borax it fuses into a transparent glass. It fuses also with biphosphate of soda, leaving a skeleton of silica. With carbonate of soda it fuses into a glass full of vesicles.

The following table exhibits the constituents of this mineral, according to the best analysis hitherto made:

	*	†	†	‡
Silica,	64	64·5	65	64·20
Alumina,	20	19·75	20	18·40
Potash,	14	11·50	12·25	16·95
Lime,	2	trace	trace	trace
Oxide of iron,	—	1·75	1·25	—
Water,	—	0·75	0·50	—
	100	98·25	99	99·55

I am disposed to take Berthier's analysis as nearest the truth, because it was made on a pure specimen, and his method of determining the potash would be more correct than the methods of Vauquelin or Klaproth. The result of this analysis gives us the following atomic numbers:

		Atoms.
Silica,	32·1	11·3
Alumina,	8·17	2·9
Potash,	2·82	1

The atoms of silica are thrice as numerous as those of the bases; while those of potash are to those of alumina, very nearly as 1 to 3. Hence the constituents of felspar are

3 atoms tersilicate of alumina,
1 atom tersilicate of potash.

The formula is $3AlS^3+KS^3$.

Sp. 32. *Glassy Felspar.*

Ryacolite.

This mineral is a very common ingredient in lava, and got its name from the strong vitreous lustre by which it is characterized. The lava of Vesuvius contains abundance of it, and also the lava of the Laucher sea. It is found also in many other localities, as the pitchstone porphyry in the islands of Arran and Rum. It was first distinguished as a peculiar species by G. Rose.

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* Vauquelin; Hauy, ii. 592.

† Klaproth, Beitrage, vi. 242. The first specimen from Carlsbad, having a specific gravity of 2·565; the second from Frederickswärn in Norway, having a specific gravity of 2·590.

‡ Berthier; Ann. des Mines, vii. 239. An adularia from St. Gothard.

Colour greyish white or grey.

It is always crystallized, and the form is the same as that of felspar, excepting that by M. G. Rose's measurement, the inclination of M on T is very nearly a degree greater than in adularia.[*] The crystals are usually very much cracked. They are generally small and always imbedded.

Fracture uneven or small imperfect conchoidal.

Internal lustre splendent and strongly vitreous; transparent.

Hardness the same as that of felspar.

Specific gravity, as determined by G. Rose, from 2·576 to 2·582.

Mitcherlich tried the optical properties of glassy felspar and found them quite different from those of adularia.

The following table exhibits the constituents of this mineral, as determined by the analyses of G. Rose and Berthier.

	[†]	[‡]	[§]	[§]
Silica, ...	65·52	50·31	66·1	66·6
Alumina, ...	19·15	29·44	19·8	18·5
Lime, ...	0·60	1·07	—	—
Magnesia, ...	—	0·23	2·0	1·0
Potash, ...	14·73	5·92	6·9	8·0
Soda, ...		10·56	3·7	4·0
Oxide of iron, . .	—	0·28	—	0·6
Volatile matter, . .	—	—	—	—
	100	97·81	98·5	98·7

The second of these analyses differs so much from the rest that we must omit it. The mean of the others gives us

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[*] See the usual crystalline forms of glassy felspar, figured by G. Rose in Poggendorf's Annalen, xv. 193.

[†] G. Rose, Poggendorf's Annalen, xxviii. 145. The specimen was from Vesuvius.

[‡] Rose. Ibid. p. 147. The specimen was from Vesuvius.

[§] Berthier's Memoires, ii. 315. The first specimen was from Mont Dore, the second from Drakenfield.

		Atoms.
Silica,	66·00	33
Alumina,	19·13	8·5
Potash,	7·45	1·24
Soda,	3·85	0·96

Glassy felspar agrees with common felspar in being composed of tersilicates, but it contains both potash and soda. The proportion of alkali to alumina is less. Its constitution is very nearly

4 atoms tersilicate of alumina,
1 atom tersilicate of potash and soda.

The formula is $4AlS^3+(\frac{5}{9}K+\frac{4}{9}N)S^3$.

Sp. 33. *Albite.*

Crumbling felspar, kieselspath, cleavelandite, pereklin.

This mineral which had been confounded with felspar, was first described and analyzed in 1806, by Hedenberg.* It was afterwards noticed by Gahn and Berzelius in 1814, under the name of *albite*;† and in 1815, two varieties of it were analyzed and described under the names of granular and radiated albite, by Eggertz.‡ Haussmann had received a specimen of it from Chesterfield in Massachusetts, during the year 1817. He drew up a description of it under the name of kieselspath, which was read to the Royal Society of Gottingen during the course of that year, and Stromeyer, at his request, made a chemical analysis of it, which he published in 1821 in his Untersuchungen (p. 300). In 1823, M. Gustav. Rose published an elaborate account of its crystalline form and constitution.§ At a latter period, Mr. Brooke proposed for it the name of cleavelandite, and Mr. W. Phillips showed that it is a common constituent of the granite rocks of this country.||

The colour is generally white, but it is found also bluish and blue, of a dingy red and green, and doubtless of other colours; streak white.

It occurs massive and also crystallized. The primary form is a doubly oblique prism.

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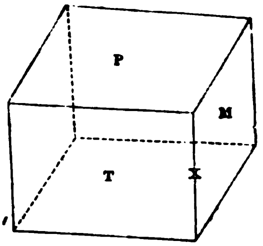
* Afhandlingar, i. 118.

† Ibid. iv. 180. The name was derived from *albus*, white; from the white colour of the specimens observed by them.

‡ Ibid. v. 27.

§ Gilbert's Annalen, lxxiii. 173.

|| Annals of Philosophy (2d series), vii. 118.



T on M 117° 53′
P on M 86° 24′
P on T 115° 5′

The edge X is often replaced by a plane, making with T an angle of 122° 15′, and with M an angle of 119° 52′. The terminal edges and angles of the prism are also occasionally replaced by planes.*

Albite, when massive, is always radiated, never foliated.

Lustre vitreous, often inclining to pearly on the perfect surfaces of cleavage.

Rarely transparent, and only when it occurs in small crystals; always translucent on the edges.

Hardness 6; brittle.

Specific gravity, by Rose's trials, varies from 2·608 to 2·619. Eggertz found the albite of Finbo 2·612, that of Broddbo 2·619. Nordenskiöld found the red albite from Kimito 2·609.

Before the blowpipe it behaves exactly like felspar.

Does not dissolve by digestion in acids.

The constituents of albite, according to the most accurate analyses hitherto made, are as follow:—

	†	‡	§	||
Silica, . . .	70·48	70·676	68·46	70·94
Alumina, . .	18·45	19·801	19·30	18·70
Soda, . . .	10·50	9·056	9·27	8·83
Lime, . . .	0·55	0·235	0·68	0·68
Oxides of iron & manganese,	—	0·111	0·28	—
Moisture, . .	—	—	—	0·70
	99·98	99·679	97·99	99·85

These four analyses approach each other very closely; showing that all the specimens analyzed were nearly pure. The mean of the four is as follows:—

		Atoms.
Silica, . .	70·139 .	35·07
Alumina, . .	19·063 .	8·47
Soda, . . .	9·414 .	2·35

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* See a description of the forms by Rose; Gilbert's Annalen, lxxiii. 156.

† Eggertz, Afhandlingar, v. 28. ‡ Stromeyer, Untersuchungen, p. 300.

§ Rose, Gilbert's Annalen, lxxiii. 173.

|| By my analysis. A beautiful white laminated mass.

The atoms of silica exceed three times the atoms of the bases by 2·61, which rather exceeds the atoms of soda. It would seem from this that the soda is in the state of quatersilicate; but it is more probable that this excess of silica is accidental, and that the constitution of albite is

3 atoms tersilicate of alumina,
1 atom tersilicate of soda.

The formula is $3AlS^3+NS^3$.

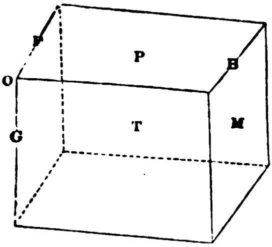
Sp. 34. *Anorthite.*[*]

This species was first recognised and separated from felspar, with which it had been confounded, by Dr. Gustavus Rose in 1823.[†]

The only locality of it at present known is Mount Vesuvius, where it is found lining cavities in limestone along with a greenish variety of pyroxene.

Colour white; streak white.

It occurs sometimes massive, but most frequently crystallized. The primary form of the crystal is a doubly oblique prism.



M on T 117° 28′
M on P 94° 12′
T on P 110° 57′

In general the edge G is replaced by a plane making an angle of 120° 30′ with T. This plane sometimes increases so much as to obliterate the plane M′ altogether. The edges F and B are often replaced by planes, which cause the prism to terminate in three planes. P makes with one of these new planes an angle of 137° 22′, and with the other an angle of 133° 13′. Sometimes the angle O is replaced by a triangular plane.

Fracture conchoidal.

Lustre on cleavage planes pearly; in other directions vitreous.

Varies from transparent to translucent; brittle.

Hardness 6; specific gravity of the massive varieties 2·762, of small crystals not quite free from pyroxene 2·656, as determined by Rose.

Before the blowpipe it fuses on the edges with great difficulty. With borax it fuses into a transparent glass. With biphosphate of soda we obtain the same result, excepting that a skeleton of silica is left. With carbonate of soda it swells and froths and forms an enamel.

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[*] The name is derived from the Greek word *ανορθος*, because the primary form exhibits no right angles.

[†] Gilbert's Annalen, lxxiii. 173, or Ann. de Chim et de Phys., xxiv. 1.

Its constituents, as determined by Dr. G. Rose, are

		Atoms.	
Silica,	44·49	22·24	10·59
Alumina,	34·46	15·31	7·29
Lime,	15·68	4·48	2·13
Magnesia,	5·26	2·10	1
Peroxide of iron,	0·74	0·15	0·07
	100·63		

The number of atoms of silica nearly correspond with those of the bases, showing that the mineral is composed of silicates. The constitution approaches

7 atoms silicate of alumina,
2 atoms silicate of lime,
1 atom silicate of magnesia.

The minute quantity of silicate of iron is doubtless accidental.

Sp. 35. *Labradorite.*

Labradore felspar.

This mineral was first observed on the island of St. Paul, near the coast of Labrador, by Mr. Wolfe. It occurs also in Ingermania, and (as Klaproth informs us) in great abundance. The hills at Campsie, near Glasgow, and on the south side of Paisley contain a great quantity of a peculiar green stone, in which labradorite supplies the place of felspar.

It was arranged as a variety of felspar by mineralogists; but Kirwan was of opinion on account of its difficult fusibility, that it constituted a peculiar species.* And Klaproth proved by analysis that the constituents differ from those of felspar.† Still more lately Dr. G. Rose showed that the crystalline form, as well as the composition, is different. We cannot hesitate then to consider it as a distinct species, though nearly related to felspar.

Colour dark ash and smoke grey, in certain positions it reflects a great variety of colours, as blue, green, yellow, red, and brown. It was these colours that first attracted the attention of the missionaries. When the stone is polished they give it a great deal of beauty.[*]

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* Mineralogy, i. 324.

† Beitrage, vi. 250.

Occurs commonly massive, and in rolled pieces, but the labradorite in the neighbourhood of Glasgow, is often in crystals; and Rose informs us that a crystallized specimen of it is placed in the mineralogical cabinet belonging to the University of Berlin. The shape of the crystal is very analogous to that of felspar. But the inclination of the sides and base are a little different. The following are the results of several measurements by Nordenskiöld:—[†]

P on M 93° 28′
P on T 114° 48′
T on M 119° 16′

Lustre of the sides of the prism vitreous, of the base pearly; translucent when in thin pieces.

Hardness 6; specific gravity of the variety from Labrador, as determined by Klaproth 2·69, as determined by my trial 2·699. Klaproth found that from Ingermania 2·75. Rose found the specific gravity of two specimens from Labrador 2·695 and 2·7025.[‡]

Before the blowpipe behaves like felspar.

Soluble when in powder, or at least decomposable by muriatic acid.

Its constituents, according to the analyses hitherto made, are as follow:—

	§	‖	¶	**
Silica, . .	55·75	55	55·408	58
Alumina, . .	26·50	24	26·920	27·3
Lime, . .	11·00	10·25	10·892	9·8
Protoxide of iron,	1·25	5·25	1·508	trace
Soda, . .	4·00	3·5	4·392	2·0
Water, . .	0·50	0·5	0·840	1·2
	99	98·5	99·96	98·3

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[*] Nordenskiöld describes a curious suite of colours displayed by a lab dorite found near Ojamo, in Finland. See Poggendorf's Annalen, xix. 1

[†] Poggendorf's Annalen, xix. 181.

[‡] Ann. de Chim. et de Phys. xxiv. 25.

[§] Klaproth, Beitrage, vi. 250. The specimen was from Labrador.

[‖] Klaproth, ibid. The specimen was from Ingermania.

[¶] By my analysis. The specimen was from Labrador.

[**] Analyzed by Mr. Bruce in my laboratory. The specimen was the hills on the south side of Paisley. It was impossible to free it fr

We must omit the fourth of these analyses, because the specimen was not quite pure. The mean of the other three gives us

		Atoms.
Silica,	55·386	27·69
Alumina,	25·810	11·47
Lime,	10·714	3·06
Protoxide of iron,	2·663	0·59
Soda,	3·964	0·99
Water,	0·613	0·54

The atoms of the bases being only 16·11, while those of silica are 27·69, it is obvious that the alumina must be in the state of bisilicate. If we admit the silicate of iron to be accidental, the constitution of the mineral will be

11½ atoms bisilicate of alumina,
3 atoms silicate of lime,
1 atom silicate of soda;

Or, it may be a simpler view of the compound to consider the silicates of lime and soda as previously united. The constitution of the mineral will then be

3 atoms bisilicate of alumina,
1 atom of silicates of lime and soda.

The formula will be $3AlS^2+(\frac{2}{3}Cal+\frac{1}{3}N)S$.

Sp. 36. *Kaolin.*

Porcelain earth, porcelain clay.

This mineral constitutes an ingredient in a kind of disintegrated granite, where the kaolin or porcelain earth assumes the place of felspar or albite. St. Austle, in Cornwall, and St. Yriez, in France, are well known localities.

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traces of hornblende. A specimen from Canada very like labradorite, and having a specific gravity of 2·461, was analyzed in my laboratory. Its constituents were

		Atoms.
Silica,	50·45	25·22
Alumina,	29·65	13·17
Protoxide of iron,	1·85	0·41
Lime,	9·95	2·84
Soda,	6·00	1·5
Water,	1·65	1·46
	99·55	

This is $10AlS^{1\frac{1}{4}}+CalS+NS^{1\frac{1}{4}}$. It is therefore not labradorite, though it approaches it.

Colour white, often with a shade of yellow or red.

Massive or disseminated in rocks.

Composed of dusty particles cohering slightly; adheres slightly to the tongue; feels meagre.

Specific gravity, as determined by Karsten, 2·216. I found that of St. Austle, Cornwall, 2·484.

Does not fuse per se.

The following table exhibits the constituents of various specimens of kaolin from different localities:

	[*]	[†]	[†]	[†]	[†]	[†]	[‡]
Silica, . .	52	46·8	58·6	55·8	63·5	50	37·10
Alumina, . .	47	37·3	34·6	26·0	28·0	25	24·48
Potash, . .	—	2·5	2·4	8·2	1·0	2·0	—
Magnesia, . .	—	trace	1·8	0·5	8·0	0·7	—
Lime, . .	—	—	—	—	—	5·5	9·28
Oxide of iron, .	0·33	—	—	1·8	—	8·5	6·98
Water, . .	—	13·0		7·2	—	9·5	19·22
	99·33	99·6	97·4	99·5	100·5	101·4	97·06

From the great difference between these different analyses, it is evident that the specimens were not pure. They were doubtless mixed with quartz, and probably also with felspar.

I consider the probable composition of kaolin to be

$$4(Al+f)S+(Cal+k)S.$$

Sp. 37. *Leelite.*

This mineral, which occurs at Grythittan in Nerike, was named by Dr. Clarke, who subjected it to a chemical analysis.[§] It had been previously considered as a compact felspar.

Colour deep flesh red.

Structure compact; fracture splintery and conchoidal.

Has the translucency of horn.

Hardness 6·25; specific gravity 2·606.

Its constituents, by my analysis, are

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[*] Rose, Karsten's tabellen, p. 37,

[†] Berthier, Ann. de Chim. et de Phys. xxiv. 107. The first specimen from St. Yriez; the second from Meissen; the third from St. Tropez; the fourth from Mende; and the fifth from Normandy.

[‡] By my analysis. The specimen was from St. Austle. The loss was probably potash.

[§] Annals of Philosophy, xi. 367.

		Atoms	
Silica,	81·91	40·95	28·83
Alumina,	6·55	2·91	2·05
Protoxide of iron,	6·42	1·42	1
Potash,	8·88	1·48	1·04
	103·76		

This is very nearly

2 atoms sepsilicate of alumina,
1 atom sepsilicate of iron,
1 atom sepsilicate of potash.

The formula is $2AlS^7+fS^7+kS^7$; or supposing the silicates of iron and potash previously combined, $AlS^7+(\frac{1}{2}f+\frac{1}{2}K)S^7$.

Berthier has given us the analysis of a mineral from Sahlberg, in Sweden, under the name of *petrosilex*, which has some resemblance to leelite.

It has a deep flesh red colour, is compact and homogeneous, the fracture resembles that of wax, and is very fine grained. It is strongly translucent, is capable of receiving a good polish, and before the blowpipe is fusible into a white enamel, though it is much more infusible than felspar. Its constituents are

		Atoms.
Silica,	79·5	39·75
Alumina,	12·2	5·42
Soda,	6·0	1·50
Magnesia,	1·1	0·44
Oxide of iron,	0·5	0·10
	99·3*	

The atoms of silica are rather more than five times as numerous as those of the bases. If we consider the oxide of iron as accidental, and unite together the magnesia and the soda, the atoms of alumina will be nearly thrice as numerous as those of soda and magnesia together. Hence the constitution of the mineral must be

3 atoms quintosilicate of alumina,
1 atom quintosilicate of magnesia and soda.

The formula will be $3AlS^5+(\frac{3}{4}N+\frac{1}{4}m)S^5$.

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[*] Ann. de Chim. et de Phys. xxxvi. 20.

Sp. 38. *Spodumene.*[*]

Triphane.

This mineral was first found in the iron mine of Utön, in the province of Södermanland, Sweden, and was described by D'Andrada. It was afterwards discovered by Leonhard, at Sterzing, in the Tyrol; more lately at Killiney, near Dublin; and I have very fine specimens from the United States.

Colour various shades of greyish green, passing into greenish white; streak white.

Texture always foliated. Cleaves in the direction of an oblique prism, with angles of 93° and 87°, but there is no cleavage to determine whether the prism be right or oblique.

Lustre pearly; translucent.

Hardness 6·5; specific gravity, by Leonhard, 3·115;[†] Haidinger states it at 3·170.[‡] I found that from Dublin bay 3·188.

Before the blowpipe it swells to a foliated reddish yellow mass, which on the smallest agitation falls to powder. The outermost portions fuse into small glass globules.

The constituents of this mineral, according to the best analyses hitherto made, are as follow:

Silica, . .	66·40 .	63·288 .	63·812
Alumina, .	25·30 .	28·776 .	28·508
Lithia, . .	8·85 .	5·626 .	5·604
Lime, . .	— .	— .	0·728
Protoxide of iron,	1·45 .	0·794 .	0·828
Protox. of mangan.,	— .	0·204 .	—
Moisture, .	0·45 .	0·775 .	0·360
	102·45[§]	99·463[‖]	99·840[¶]

These analyses approach very near to each other, showing that the specimens examined were pure or nearly so.

The mean of the three gives us

		Atoms.
Silica, .	64·5 .	32·25
Alumina, .	27·528 .	12·23
Lithia, .	6·69 .	3·82

It is obvious that the atoms of silica are twice as numerous as those of the bases. The atoms of lithia are more than a fourth of the atoms of alumina, owing to the excess of that alkali in Arfvedson's analysis. In the other two analyses it approaches very near to a fourth. We may therefore consider spodumene as composed of

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[*] From σποδος, *ashes*. So called because it assumes a form like ashes before the blowpipe.

[†] Ann. des Mines, iii. 125.

[‡] Mohs' Mineralogy, ii. 217.

[§] Arfvedson, Afhandlingar, vi. 161.

[‖] Stromeyer, Untersuchungen, p. 426.

[¶] From Killiney, Dublin Bay, analyzed by Captain Lehunt, in my [illegible].

4 atoms bisilicate of alumina,
1 atom bisilicate of lithia.

The formula is $4AlS^2+LS^2$.

Sp. 39. *Petalite.*[*]

Berzelite.

This mineral, like the preceding, was first observed by D'Andrada, in the iron mine of Utön, where it is said to constitute a vein. I have seen specimens also from the United States.

Colour milk-white, sometimes with a shade of red or flesh-red. Sometimes it is greenish, probably from an admixture of chlorite. Streak white.

Occurs only massive; lamellar in one direction. It has a two-fold cleavage parallel to the faces of a prism of 100° and 80°, according to Brooke. Mr. Phillips thinks that the summit of the prism is oblique.

Lustre vitreous, inclining to resinous. It inclines to pearly upon the perfect faces of cleavage.

Translucent; brittle.

Hardness 6·5; specific gravity, as determined by Arfvedson 2·42,[†] by Dr. Clarke 2·45,[‡] by C. G. Gmelin 2·426.[§]

Exposed to the heat of the blowpipe on charcoal, it becomes glassy, semitransparent, and white; but melts with difficulty, and only on the edges. With borax it fuses into a clear colourless glass.

When gently heated it emits a blue phosphorescent light.

When boiled in acids it is partly decomposed.

Its constituents, according to the analyses of Arfvedson and Gmelin, are as follow:

Silica,	79·212	74·17
Alumina,	17·225	17·41
Lithia,	5·761	5·16
Lime,	trace	0·32
Water,	—	2·17
	102·198[‖]	99·23[¶]

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[*] From πεταλον, *a leaf.*

[†] Afhandlingar, vi. 147.

[‡] Annals of Philosophy, xi. 198.

[§] Ibid, xv. 341.

[‖] Arfvedson, Afhandlingar, vi. 145.

[¶] C. G. Gmelin, Annals of Philosophy, xv. 343.

There seems to have been an excess of silica in the specimen analyzed by Arfvedson. Gmelin's analysis gives us

		Atoms.
Silica, .	37·08 .	12·6
Alumina, .	7·73 .	2·62
Lithia, .	2·94 .	1

If we were to admit 0·6 of alumina to be combined with 0·6 silica, and to be accidental, petalite would consist of

2 atoms quatersilicate of alumina,
1 atom quatersilicate of lithia.

The formula is $2AlS^4+LS^4$.

The last described eleven species in this section were originally confounded together under the name of felspar, though they all differ in their chemical constitution, and in their crystalline form. It may be worth while to give a synoptical view of the primary crystal, and of the composition of these eleven species, that the student may be enabled to distinguish them readily from each other.

	Murchisonite.	Gabronite	Spodumene.	Anorthite.	Albite.	Labradorite.	Felspar.	Glassy felspar.	Kaolin.	Leelite.	Petalite.
M on T	90°	90°	93°	117°28′	117°53′	119°16′	120°35′	121°35′	Does not crystall.	not crystallized.	100°
P on M	106°50′	99°	—	94°12′	86°24′	93°28′	90°	Unknown.			Unknown.
P on T	90°	90°	—	110°57′	115° 5′	114°48′	67°15′				

The constituents are as follow:

Murchisonite,	$3AlS^{3\frac{1}{4}}+KS^{3\frac{1}{4}}$.
Gabronite,	$3AlS^2+(K,N)S^2$.
Spodumen,	$4AlS^2+LS^2$.
Anorthite,	$7AlS+2CS+MS$.
Albite,	$3AlS^3+NS^3$.
Labradorite,	$3AlS^2+(\frac{2}{3}C+\frac{1}{3}N)S$.
Felspar,	$3AlS^3+KS^3$.
Glassy felspar,	$4AlS^3+(\frac{5}{9}K+\frac{4}{9}N)S^3$.
Kaolin,	$4(Al+f)S+(C+K)S$.
Leolite,	$2AlS^7+fS^7+KS^7$.
Petalite,	$2AlS^4+LS^4$.

Sect. 4. *Double hydrous Aluminous Salts soluble in Water.*

These salts are not numerous, as they amount only to three, constituting the different species of *alkaline alum* known in commerce.

Sp. 1. *Ammonia-Alum.*

This alum, which approaches very nearly in its properties to the common potash-alum of this country, occurs at Tackermig, in Bohemia, and was described by Von Herder, in the year 1818.*

It has a greyish-white colour; occurs amorphous, but by solution and evaporation may be obtained in regular octahedrons.

Lustre resinous and shining.

Structure fibrous; cross fracture conchoidal.

Varies from transparent to translucent.

Soft; specific gravity 1·56 at the temperature of 44°·5.

Has the look of alum, is soluble in water, and when heat is applied exhibits nearly the same phenomena as common alum.

Its constituents, according to the analysis of Mr. mine-commissioner Gruner, are,

Sulphuric acid,	33·682	or	19·24
Alumina, .	10·750		6·31
Ammonia, .	3·619		2·125
Water, .	51·000		29·94
	99·051†		

These approach very nearly to

4 atoms sulphuric acid,	20
3 atoms alumina, .	6·75
1 atom ammonia, .	2·125
25 atoms water, .	28·125

Hence the constituents are doubtless

3 atoms sulphate of alumina,
1 atom sulphate of ammonia,
25 atoms water.

At least these are the constituents of ammonia-alum, when made artificially.

Sp. 2. *Potash-Alum.*

This salt occurs occasionally, though rarely, in pretty regular octahedral crystals. I have specimens of it from the neighbourhood of Whitby, and from Mount Etna.

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* Gilbert's Annalen, lxix. 54.

† Ibid. 218.

It is white and translucent, or transparent. The crystal is the regular octahedron, having frequently all its angles replaced by tangent planes.

Hardness 2·75; specific gravity 1·753.

Taste sweetish, astringent, and acid.

Reddens vegetable blues and is soluble in water.

Melts when heated; before the blowpipe froths up and swells, and at last loses its acid.

Its constituents are

3 atoms sulphate of alumina, .	21·75
1 atom sulphate of potash, .	11·00
25 atoms water, . . .	28·125
	60·875

This is the species of alum usually manufactured in Great Britain.

Sp. 3. *Soda-Alum.*

This species of alum occurs native in the Province of St. Juan, situated to the north of Mendoza, on the east side of the Andes, in about south latitude 30°. The specimens which I examined were sent to Dr. Hooker by Dr. Gillies of Edinburgh, who at that time lived in Mendoza.

It is white, and composed of fibres adhering longitudinally, and having a certain breadth, but very thin. It bears some resemblance to fibrous gypsum, but is harder, not being scratched by the nail.

Sectile; outer fibres white, and only slightly translucent, as if they had lost a portion of their water. But the internal fibres are transparent, and have a glassy, or rather a silky aspect, showing that they retain water of crystallization.

Specific gravity of the transparent portion 1·88; hardness 3.

Tastes precisely like alum; very soluble in water. At 62° 100 parts of water dissolve 377·3 parts of the alum, and boiling water dissolves any quantity whatever. When exposed to heat, it exhibits nearly the same phenomena as common alum.

I found its constituents

Sulphuric acid, .	20·000
Alumina, . .	6·360
Silica, . . .	0·012
Lime, . . .	0·136
Peroxide of iron, .	0·110
Protoxide of iron, .	0·423
Soda, . . .	4·000
Water, . .	22·209
	53·250

The sulphuric acid constitutes 4 atoms.

The alumina wants 0·29 of three atoms, but the quantity of lime and oxides of iron present are just equivalent to 0·29 alumina, and are substituted for it.

The soda constitutes 1 atom.

The water is only 0·291 less than 20 atoms. Hence it is obvious that the true constitution of this salt is

3 atoms sulphate of alumina,	21·75
1 atom sulphate of soda, .	9
20 atoms water, .	22·50
	53·25

It contains 5 atoms of water less than soda-alum, artificially crystallized.

Sect. 5. *Double Hydrous Aluminous Sulphates and Phosphates insoluble in Water.*

These species amount only to three. I place them by themselves, because they do not well agree with the minerals in the other sections of this genus.

Sp. 1. *Alumstone.*

Walnyn.

This mineral was first observed at Tolfa, in the neighbourhood of Rome; afterwards in Hungary; and Cordier has shown that it is very common in volcanic rocks, but that it never occurs any where else.*

Colour white, greyish-white, or sometimes yellowish-white.

Most commonly amorphous, but it is observed also crystallized in rhomboids approaching very near to cubes, the angles being 89° and 91°. In some crystals the apex of the rhomboid is replaced by tangent planes. The size of these crystals varies from 0·03937, to 0·11811 of an inch in length.

Hardness 3·5; specific gravity 2·7517. The amorphous specimens (owing, probably, to cavities) are lighter; Hauy states it as 2·587.

Fracture foliated in a direction perpendicular to the axis of the rhomboid. In all other directions the fracture is conchoidal.

Lustre vitreous; fragments irregular, with blunt edges; Easily pulverized.

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* Ann. des Mines, iv. 205, and v. 303.

Feels harsh, and does not stain.

Decrepitates before the blowpipe. Gives out sulphurous acid when heated on platinum foil, and tastes of alum when applied to the tongue. In a strong heat loses its acid and becomes tasteless.

The constituents of the pure crystals, according to the analysis of Cordier, are

		Atoms.	
Sulphuric acid,	35·495	7·1	4·25
Alumina,	39·654	17·61	10·54
Potash,	10·021	1·67	1
Water and loss,	14·830	13·18	7·96
	100		

These atomic numbers approach pretty nearly

3 atoms trisulphate of alumina,
1 atom sulphate of potash,
8 atoms water.

From the mode of analysis followed, a little of the potash would remain adhering to the alumina. Hence the apparent excess of alumina and of sulphuric acid.

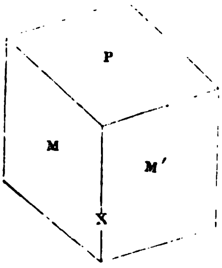
Sp. 2. *Wavellite.*

Devonite, hydrargillite, lasionite, hydrous diphosphate of alumina.

This mineral was discovered a good many years ago by Dr. Wavell, in small veins and in cavities, in a tender clay slate near Barnstaple in Devonshire; and it was named by Dr. Babington from the discoverer.

Its colour is white, passing into various shades of green, grey, yellow, brown, and black.

It is found almost always in minute crystals, which commonly adhere together, forming hemispherical or globular concretions, from a very small size to an inch, or even more, in diameter. The primary form of the crystal is a right rhombic prism, in which M on M′ is 122° 15′.



The base P is usually replaced by a dihedral summit, the faces of which are inclined on each other at an angle of 107° 26′. The edge X is frequently replaced by two, and sometimes by four planes.

Lustre of cleavage planes intermediate between pearly and vitreous.

Hardness 3·25; specific gravity of the variety from Barnstaple 2·337;[*] of the variety at St. Stephens, Cornwall, 2·253;[†] of the Irish variety 2·3616, as determined by Mr. Richardson.

Before the blowpipe it loses its lustre and transparency, but does not melt. With boracic acid and iron wire it yields a globule of phosphuret of iron.

The constitution of this mineral was discovered by Fuchs, and his analysis was confirmed by that of Berzelius. The following table shows the results obtained.

	‡	§	‖
Phosphoric acid,	35·12	33·40	34·65
Fluoric acid,	—	2·06	—
Alumina,	37·20	35·35	34·00
Lime,	—	0·50	—
Oxides of iron & manganese,	—	1·25	2·15
Water,	28·00	26·80	28·75
	100·37	99·36	99·55

These analyses give us as the constitution of wavellite,

9 atoms diphosphate of alumina,
$\frac{1}{2}$ atom bifluate of alumina,
$14\frac{1}{2}$ atoms water.

Or doubling the number to get rid of fractions,

18 atoms diphosphate of alumina,
1 atom bifluate of alumina,
29 atoms water.

But Mr. Richardson's analysis, which was made with very great care upon a pure specimen, gives

$1\frac{1}{2}$ atom phosphoric acid,
3 atoms bases,
5 atoms water.

Hence the formula will be $3\mathrm{Al}^2\dot{\mathrm{P}}\mathrm{h}+5\mathrm{Aq}$.

This mineral has been found near Cork in Ireland, in the Shiant Isles, Scotland; in Brazil, Bohemia, Mount Vesuvius, and various other localities.

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[*] Haidinger, Mohs' Mineralogy, iii. 170.

[†] Gregor, Nicholson's Jour. xiii. 249.

[‡] Fuchs, Schweigger's Jour. xxiv. 121.

[§] Berzelius, Ann. de Chim. et de Phys. xii. 12.

[‖] The Irish variety analyzed in my laboratory, by Mr. Richardson.

Sp. 3. *Lazulite.*

Azurestone. Hydrous diphosphate of alumina and magnesia.

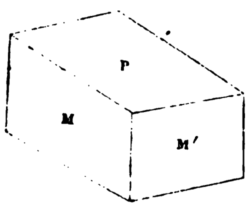
This mineral occurs near Werfen in Salzburg, in the valleys called Schlamming and Radelgraben, in narrow veins traversing clay slate.

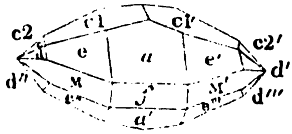
The colour of the mineral is pale blue of various shades; particularly deep and beautiful if viewed in the direction of one line, apparently the axis of the crystal; while perpendicular to it, it is of a pale greenish blue colour; streak white.

It is most frequently granular or in pieces, about the size of a hazel nut, but it occurs also crystallized. The primary form of the crystal is a regular rhombic prism.

M on M′ 121° 30′

According to the measurement of Mr. W. Phillips. In general the edges are replaced by one or more planes. We give a representation of a superb crystal in the possession of Mr. Brooke, with the inclinations of the planes as measured by Mr. William Phillips.





M on e or M′ on e′	138°	45′
M on d, . .	140	30
M or M′ on *f*, .	150	45
a on *a*′, . .	91	30
a on cl or cl′, . .	129	10
a on e or e′ or *a*′ on e″ or e‴,	158	10
cl on cl′, . .	120	40
cl on c2′ or cl′ on c2′	150	
e on d or e′ on d′, .	162	36
cl on e or cl on e′, .	139	25
cl on d, . .	141	20

Fracture uneven; surface smooth, all the faces alike.

Lustre vitreous; translucent, at least on the edges; sometimes opaque.

Hardness 5 to 5·5; brittle; specific gravity, as determined by Fuchs, 3·057.

Before the blowpipe it intumesces a little, and assumes a glassy appearance when the heat is highest, but does not melt. With borax it yields a clear colourless globule. Treated with boracic acid and a piece of iron wire, it gives a globule of phosphuret of iron.

Its constituents, as determined by Fuchs, are as follow:

		Atoms.	
Phosphoric acid,	41·81	9·29	2·52
Alumina,	35·73	15·88	4·25
Magnesia,	9·34	3·78	1
Silica,	2·10	1·05	0·28
Protoxide of iron,	2·64	0·58	0·15
Water,	6·06	5·38	1·44
	97·68*		

The atoms of acids (including the silica) amount to half the atoms of the bases. Hence the mineral is composed of disalts. Supposing the silica to be united with alumina and oxide of iron, and that these disilicates are accidental, lazulite will be

4 atoms diphosphate of alumina,
1 atom diphosphate of magnesia,
1½ atoms water.

Whether the mineral which occurs at Vorau in Austria, and described and analyzed by Klaproth in 1792,† be the same with the mineral here described, remains to be determined. From Mr. Brooke's measurement, its crystals are right rhombic prisms with angles of 121° 30′, and 58° 30′.

Sp. 4. *Bluespar.*

Prismatoidal azure spar, feldspath bleu of Hauy.

This mineral occurs in masses and in indistinct crystals imbedded in quartz, and mixed with mica, in the valley of Freschnitz near Krieglach on the Mürz in Upper Stiria.

Colour smalt blue, inclining sometimes to white or green; streak white.

The crystals, by Hauy's description, seem to be right oblique prisms; cleavage indistinct; fracture uneven.

Lustre vitreous, inclining to pearly on faces of cleavage.

Translucent on the edges; often nearly opaque.

Brittle; hardness 5½ to 6; specific gravity 3·024, as determined by Haidinger.

Before the blowpipe it loses its colour but does not melt. It dissolves slowly and with difficulty in borax. With boracic acid and iron wire it yields a globule of phosphuret of iron.

Its constituents, as determined by Brandes, are

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* Schweigger's Jour. xxiv. 373.

† Beitrage, i. 197.

		Atoms.
Phosphoric acid,	43·32	9·62
Silica,	6·50	3·25
Alumina,	34·50	15·33
Magnesia,	13·56	5·42
Lime,	0·48	0·13
Protoxide of iron,	0·80	0·17
Water,	0·50	
	99·66	

There can be no doubt that it is a diphosphate of alumina and magnesia like the preceding species. The silica, lime, and protoxide of iron, are most probably accidental ingredients derived from the rock. The constituents are

3 atoms diphosphate of alumina,
1 atom diphosphate of magnesia.

The difference between lazulite and blue spar lies in the proportion of the two diphosphates which each contains.

Sect. 6. *Double Hydrous Aluminous Silicates*, or *Zeolites*.

The term *zeolite* was first applied by Cronstedt, to a mineral which he describes as frothing and swelling before the blowpipe like borax. The specimens which he describes were from Svappavari in Torneo Lappmark, and from Iceland.* Hauy afterwards divided the zeolite of Cronstedt into 4 species.† Since that time many additions have been made to their number. I mean to class under the common name of zeolites all the double hydrous aluminous silicates. They owe their property of frothing when heated, to the water which they contain. This water is easily driven off by a heat scarcely amounting to ignition, and on its escape, the mineral either falls to powder or melts into a white enamel, according to the nature of the constituents. They occur most frequently in trap rocks, especially amygdaloid, and in lava. The hills in the neighbourhood of Glasgow and in the north of Ireland, are particularly rich in species belonging to this beautiful section of the mineral kingdom. The species belonging to the zeolites amount at present to no fewer than 38.

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* Kong. Vet. Acad. Handl., 1756, p. 120. It was from the frothing before the blowpipe that the word *zeolite* is derived, from the Greek word ζεω, *to boil.*

† Jour. des Mines, iii. 14, 86.

Sp. 1. *Stellite.*[*]

This mineral has hitherto been observed only in the rifts of a greenstone rock, situated on the banks of the Forth and Clyde Canal, a little to the east of Kilsyth. Quantities of this rock had been blasted and brought to the neighbourhood of Glasgow. My son accidentally observed the stellite on one of these rocks while we were walking along the canal bank.

Colour snow-white.

It consists of a congeries of small crystals issuing like rays from several centres. Each circle of crystals may be about an inch in diameter. The different circles run into each other, so that the termination of each crystal is confused. They seem oblique four-sided prisms; but their inclinations cannot be measured.

Tough, having some slight resemblance to asbestus, or still more to nemalite.

Lustre silky, shining; translucent.

Hardness 3·25; specific gravity 2·612.

Before the blowpipe fuses into a beautiful white enamel. With carbonate of soda fuses with effervescence into a translucent white bead. With borax it fuses into a perfectly transparent glass when the quantity of stellite is small; if it be larger, the bead exhibits a silica skeleton. With biphosphate of soda it fuses very slowly and imperfectly into a colourless bead. But a great deal of white matter remains undissolved.

Its constituents, by my analysis, are

		Atoms.	
Silica,	48·465	24·23	10·84
Lime,	30·960	8·84	3·96
Magnesia,	5·580	2·23	1·0
Alumina,	5·301	2·31	1·03
Protoxide of iron,	3·534	0·78	0·35
Water,	6·108	5·42	2·43
	99·948		

The constituents are very nearly

11 atoms silica,
4 atoms lime,
1 atom magnesia,
1 atom alumina,
2½ atoms water.

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[*] From *stella, a star,* because the crystals spread in a star-like form on the greenstone.

The constitution of stellite seems to be

4 atoms bisilicate of lime,
1 atom bisilicate of magnesia,
1 atom silicate of alumina,
2½ atoms water.

The formula is $4CS^2+MS^2+AlS+2\frac{1}{2}Aq$.

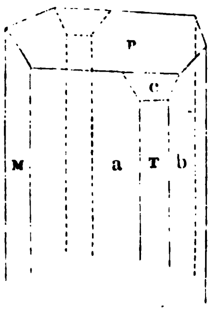
Sp. 2. *Thomsonite.*

Mesotype of Hauy in part—needle zeolite of Werner in part.

This mineral was first recognised as a peculiar species by Mr. Brooke, who determined its characters. It occurs at Lochwinnoch, and near Kilpatrick, both of which localities are within a few miles of Glasgow, and in both places it is imbedded in an amygdaloidal rock.

Colour snow-white.

Occurs usually crystallized; but there is a brown coloured amorphous mineral found at Ballimony, in Ireland, and having a specific gravity of 2·289, which proved upon analysis to be an impure variety of the same species. The primary form of its crystal, as Mr. Brooke has shown,* is a right rectangular prism, with a square base. The usual crystal is that represented in the margin, in which P, M and T are the primary faces. The faces *a*, *b* are tangents to the lateral edges of the prism, and the faces *c* are the result of a decrement of one row on the edge of the terminal plane. The height of the prism is equal to about four times its breadth.



M on a 135° 30′
a on a 90° 40′

Structure foliated; cleaves readily parallel to the faces M, T; fracture uneven.

Lustre vitreous, inclining to pearly.

From transparent to translucent.

Hardness 4·75; brittle.

Specific gravity from 2·29 to 2·36966.

Before the blowpipe it swells up like borax, and becomes opaque and snow-white, but does not melt. When exposed to a red heat it becomes opaque, very white and shining like enamel. The edges are rounded, but it does not altogether lose its shape.

The following table exhibits the constituents of this mineral, according to the best analyses hitherto made:

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* Annals of Philosophy, xvi. 194.

	*	*	†	†	‡
Silica, . . .	36·80	37·560	34·63	37·08	38·30
Alumina, . .	31·36	31·960	32·35	33·02	30·20
Lime, . .	15·40	15·096	18·65	10·75	13·54
Magnesia, . .	0·20	1·080	—	—	—
Protoxide of iron,	0·60	0·720	—	—	—
Soda, . . .	—	—	1·25	3·70	4·53
Water, . .	13·00	13·200	14	13·00	13·10
	97·36	99·616	100·88	97·55	100·07

I consider the first specimen analyzed by me as the purest specimen hitherto examined, and the second analysis as the most correct. It gives us the atomic constituents of thomsonite as follow:

		Atoms.
Silica, .	18·78 .	3·96
Alumina, .	14·20 .	3
Lime, .	4·31 .	0·91
Magnesia, .	0·43 .	0·09
Protoxide of iron,	0·16 .	0·03
Water, .	11·73 .	2·47

These numbers, if we include the magnesia along with the lime, and leave out the oxide of iron as accidental, are very nearly equivalent to

3 atoms silicate of alumina,
1 atom silicate of lime,
$2\frac{1}{2}$ atoms water.

The formula is $3AlS+CalS+2\frac{1}{2}Aq$.

Sp. 3. *Natrolite.*[§]

Mesotype, crocalite, edelite, hoganite, feather zeolite.

This mineral was first distinguished from the tribe of zeolites by Hauy, who gave it the name of *mesotype.*[‖] Klaproth analyzed a mamillary matter from Högau, near the lake of Constance, of a light yellowish brown colour, to which he gave

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[*] By my analysis. The specimens were from Lochwinnoch, near Greenock. The first analysis was inserted in the Annals of Philosophy, xvi. 409. The second was made with great care on a specimen from the same locality, to determine whether it contained an alkali.

[†] Also by my analysis. The specimens were from the neighbourhood of Dumbarton.

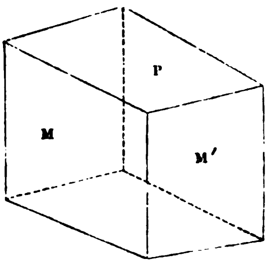
[‡] Berzelius, Edinburgh Journal, vii. 9.

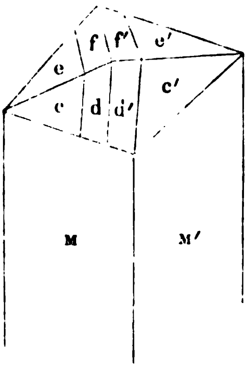
[§] From *natron*, *soda*, on account of the great quantity of soda which it contains.

[‖] Jour. des Mines, xiv. 86.

the name of *natrolite.*[*] Mr. Smithson sometime afterwards demonstrated by analysis that natrolite and mesotype belong to the same species.[†] Fuchs and Gehlen soon after showed that the mesotype of Hauy constitutes in fact two distinct species.[‡] To the one now under consideration they gave the name of *mesotype*, to the other that of *scolezite*. Still more lately Mr. Brooke, without being aware of what these chemists had done, drew precisely the same conclusion,[§] distinguishing *scolezite* by the name of *needlestone.*

Colour white, sometimes with a shade of red or brown; often grey; streak grey.





It occurs pulverulent, fibrous and crystallized. The primary form, obtained by cleavage, is a right rhombic prism.

M on M′ 91° 10′, by the measurement of Gehlen and Fuchs, and also of Mr. Brooke. The crystal is almost always terminated by a four-sided pyramid, or very commonly by eight faces, constituting two four-sided pyramids of different inclinations.

M on c	116°	37′
c on e	126	47
c on d	178	45
c on c′	143	14
d on d′	145	44

These are the measurements of Mr. Brooke. Those given by Mr. William Phillips are slightly different.[||]

Lustre vitreous; transparent to translucent; brittle.

Hardness 4·5; specific gravity from 2·139 to 2.2303. The last was a very fine crystallized specimen from Auvergne, the analysis of which is given below.

When heated it becomes electric.

Before the blowpipe froths, gives a phosphorescent light, and melts into a white semitransparent enamel.

Gelatinizes in acids, even after exposure to a red heat.

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[*] Beitrage, v. 44.

[†] Phil. Trans. 1811, p. 171.

[‡] Schweigger's Jour. xviii. 11.

[§] Annals of Philosophy, xvi. 193.

[||] Mineralogy, p. 123.

Its constituents, by the best analyses hitherto made, are as follow:

	[*]	[†]	[‡]	[§]	[‖]
Silica, . .	48	48	48·04	49	47·56
Alumina, .	24·25	26·5	25·03	27	26·42
Protoxide of iron,	1·75	—	—	—	0·58
Soda, . .	16·50	16·2	16·76	17	14·932
Lime, . .	—	—	—	—	1·400
Water, .	9·00	9·3	9·65	9·5	10·440
	99·50	100	99·48	102·5	101·332

The first three analyses very nearly agree. If we take mine, which was that of a very fine and pure specimen, we have the atomic proportions as follow:

		Atoms.
Silica, . .	24·02 .	5·73
Alumina, .	11·12 .	2·65
Soda, . .	4·19 .	1
Water, . .	8·57 .	2·04

The alumina is rather less than three atoms, but the quantity obtained by Smithson, and by Fuchs and Gehlen, was greater than in my analysis. It would seem then that natrolite is composed of

3 atoms silicate of alumina,
1 atom tersilicate of soda,
2 atoms water.

The formula is $3AlS+NS^3+2Aq$.

Sp. 4. *Mesolite.*[¶]

Perhaps this mineral should rather be considered as a variety of *natrolite*, than as a peculiar species. It possesses the crystalline form of natrolite, but in several of its other characters it approaches much nearer to scolezite. Fuchs and Gehlen first pointed it out as a peculiar species, and gave it the name which it bears, because they considered it as intermediate between natrolite and scolezite.

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[*] Klaproth, Beitrage, v. 44.

[†] Fuchs and Gehlen, Schweigger's Jour. xviii. 11.

[‡] By my analysis. A fine specimen from Auvergne.

[§] Smithson, Phil. Trans. 1811, p. 171.

[‖] By my analysis. The specimen was from Antrim. It was crystallized; but full of holes, through which water containing iron seems to have filtered. Specific gravity 2·139.

[¶] From *μεσος, middle*, and *λιθος, a stone*. Because it is intermediate between natrolite and scolezite.

It occurs in the same situations as natrolite and scolezite, in amygdaloidal cavities, and is much more common than either of them. By far the greater number of specimens of zeolite from Iceland and the Faroe islands belong to it. Most of the needlestones found in the amygdaloidal rocks in Scotland belong to it likewise.

Colour white.

Usually crystallized in four-sided prisms terminated by four-sided pyramids. The primary form is a right rhombic prism, M on M′ 91° 25′, according to Fuchs and Gehlen, 91° 10′ according to Brooke.

The lustre, transparency, hardness, electric properties, and the action of acids on mesolite, are the same as in scolezite.

Specific gravity, as determined by Dr. Freysmuth, 2·333.[*] I found it to vary in different specimens from 2·125 to 2·218.

Before the blowpipe it becomes opaque and curls up, but not so much as scolezite, neither does it give out quite so much light. It melts with the extrication of many air bubbles into a porous and almost opaque bead.

Its constituents, as determined by the best analyses hitherto made, are as follow:—

	†	†	†	†	‡	§
Silica, . .	47·00	46·78	47·46	46·04	48·028	42·188
Alumina, . .	26·13	25·66	25·35	27·00	26·660	30·412
Lime, . .	9·35	10·06	10·04	9·61	5·472	4·908
Soda, . .	5·47	4·79	4·87	5·20	8·320	12·548
Water, . .	12·25	12·31	12·41	12·36	11·720	10·966
	100·2	99·6	100·13	100·21	100·2	101·018

There are two differences between the constitution of mesolite and natrolite. It contains more water, and part of the soda is replaced by lime. Its constituents may be stated thus:

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[*] Schweigger's Jour. xxv. 426.

† Fuchs and Gehlen. The first specimen was from Faroe, and was needleform. The second and third were from Iceland, and were fibrous. The fourth was from the Tyrol, and also fibrous.

‡ By my analysis. The specimen was from the neighbourhood of Kinross.

§ By my analysis. The specimen was from Antrim. It was a white coloured mass composed of minute crystals. Specific gravity 2·125. Its constituents deviate a good deal from the rest.

3 atoms silicate of alumina,
1 atom tersilicate of lime and soda,
3 atoms water.

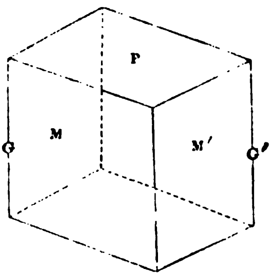
It seems to consist of a mixture or combination of natrolite and scolezite, probably only a mixture, as the proportion between the lime and soda varies a good deal in the different analyses.

Sp. 5. *Scolezite.*

Needlestone.

This species was first distinguished from mesotype, with which it had been previously confounded, by Fuchs and Gehlen, who pointed out the peculiarity of its crystalline shape, and its composition in 1816.* Mr. Brooke described its crystalline form, and recognised it as a peculiar species in 1820,† without being aware of what had been already done by Fuchs and Gehlen.

Scolezite occurs in Iceland, the Faroe Islands, Staffa, &c., in the vesicular cavities of amygdaloid. It occurs also in veins in Kilpatrick hills.



Colour white.

Usually crystallized. Primary form a right rhombic prism.

M on M′ 91° 20′, as measured by Fuchs and Gehlen, and by Brooke. The prisms are larger than those of natrolite, and their faces are smoother and more brilliant. The prism is often six-sided by the replacement of the edges G G′ by tangent planes. The prism is frequently terminated by a four-sided pyramid, the faces of which make an angle of 116° 35′ with the corresponding faces of the prism. The needles are often too small to admit of measurement.

Lustre vitreous; scratches glass feebly; specific gravity, as determined by Fuchs and Gehlen 2·214. Mr. Brooke states it at 2·27.

Soluble in nitric and muriatic acid before, but not after ignition.

Becomes electric when heated, the apex of the terminating pyramid being positive, the other extremity negative.

Before the blowpipe in the exterior flame it becomes opaque, and then twists itself up like a worm.* If the action of the exterior flame be continued for some time, the fragment melts into a very bulky and shining slag. When this slag is exposed to the interior flame, it falls down and is converted into a vesicular and slightly translucent bead.

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* Schweigger's Jour. xviii. 13.

† Annals of Philosophy, xvi. 193.

The constituents of scolezite, as determined by Fuchs and Gehlen, are as follow :—

	†	†
Silica,	46·19	46·75
Alumina,	25·88	24·82
Lime,	13·86	14·20
Soda,	0·48	0·39
Water,	13·62	13·64
	100·03	99·80

I analyzed a specimen in my cabinet, locality unknown; the result was almost identical with the first analysis of Fuchs and Gehlen. The mean of these two analyses is,

		Atoms.	
Silica,	46·47	23·23	5·80
Alumina,	25·35	11·26	2·81
Lime,	14·03	4·00	1
Soda,	0·43	0·40	0·10
Water,	13·63	12·11	3·03

This approaches sufficiently near

3 atoms silicate of alumina,
1 atom tersilicate of lime,
3 atoms water.

So that it differs from natrolite by the substitution of lime for soda, and by the addition of another atom of water. This is the reason why mesolite, which is a mixture of natrolite and scolezite, contains more water than the former of the minerals, and less than the latter.

Sp. 6. *Zeuxite*.‡

The mineral which I distinguish by this name was found in 1814 in considerable quantity in the Huel Unity mine, about three miles east of Redrath, in Cornwall. At that time

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[*] Hence the name *scolezite*, from σκωληξ, a *worm*.

[†] Schweigger's Jour. xviii. 16. The first specimen from Faroe, the second from Staffa.

[‡] From ζευξις, *connexion*, because it occurs in the *united mines*, Cornwall.

I considered it as a variety of *asbestous actinolite* of Werner, and published an analysis of it under that name.* But a more careful examination, and a more accurate analysis of it have satisfied me that it constitutes a peculiar species, which I have called *zeuxite*, in allusion to the Huel Unity where it was found.

Colour brown with a slight shade of green, when we view a considerable mass of it together, but not perceptible in a single crystal.

Composed of very small flat rectangular prisms interwoven in such a way as to leave cavities between them. From this structure the mineral may be called promiscuous fibrous.

Lustre vitreous, glistening; opaque.

Hardness 4·25; but the crystals adhere to each other so loosely that the mineral is easily crumbled between the fingers.

Specific gravity 3·051.

When heated in a glass tube it gives out water containing a trace of muriatic acid, and emits an odour which may be termed bituminous. By this treatment it loses rather more than five per cent. of its weight. Before the blowpipe its colour becomes deeper, and the crystals lose their edges and assume a scoriaceous appearance, but I did not succeed in fusing them into a glass globule. With carbonate of soda it fuses easily into an opaque bottle green glass. With borax it effervesces, and is converted into a dark brown glass so very deep in the colour that it appears opaque.

Its constituents, by my analysis, are,

		Atoms.	
Silica,	33·480	16·74	23·9
Alumina,	31·848	14·15	20·2
Protoxide of iron,	26·010	5·78	8·25
Lime,	2·456	0·70	1
Water,	5·280	4·68	6·68
	99·074		

If we admit the atom of lime to be united with 1½ atom protoxide of iron in the state of sesquiferrite of lime, and to be accidental, the mineral will be a compound of

3 atoms silicate of alumina,
1 atom disilicate of iron,
1 atom water.

The formula is $3AlS+f^2S+1Aq$.

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* Annals of Philosophy, iv. 299.

Sp. 7. *Ittnerite.*

This mineral was first described by M. Von Ittner, and it was considered as a variety of sodalite till Dr. C. G. Gmelin analyzed it, and pointed out its peculiar characters. It has hitherto been found only at Kayserstuhl, near Freyburg, in Saxony.

Colour bluish, smoke, and ash grey.

Occurs massive, and seemingly in rhomboidal dodecahedral crystals.

Fracture between imperfect conchoidal and uneven.

Lustre resinous, slightly approaching vitreous.

Hardness 7; specific gravity 2·3854.

Before the blowpipe per se fuses easily with frothing, and the evolution of a gas like sulphurous acid, and forms a vesicular opaque glass, which becomes blue when treated with nitrate of cobalt. With borax it fuses easily into a colourless translucent glass. With biphosphate of soda it is readily decomposed leaving a silica skeleton. With carbonate of soda it fuses into an opaque glass. When heated in a glass tube it gives out much water.

It readily gelatinizes in acids.

Its constituents, by Gmelin's* analysis, are,

		Atoms.	
Silica,	34·016	17·008	11·41
Alumina,	28·400	12·62	8·47
Lime,	5·235	1·49	1
Soda,	11·288	2·82	1·88
Potash,	1·565	0·26	0·17
Peroxide of iron,	0·616	0·12	0·08
Gypsum,	4·891	—	—
Common salt,	1·618	—	—
Water with some sulphuretted hydr.,	10·759	9·56	6·41
	98·388		

The gypsum and common salt are doubtless accidental ingredients. The other ingredients are

8½ atoms silicate of alumina,
2 atoms silicate of soda,
1 atom silicate of lime,
6½ atoms water.

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* Schweigger's Jahrbuch, vi. 74.

If we allow for a small deficiency of silicate of alumina, the constituents might be thus arranged:—

3 atoms silicate of alumina,
1 atom silicate of soda and lime,
2 atoms water.

The formula would then be $3AlS+(\frac{2}{3}N+\frac{1}{5}Cal)S+2Aq$.

Sp. 8. *Plinthite.**

I give this name to a mineral which occurs in the County of Antrim, in Ireland, from its brick red colour.

Colour brick red.

Texture earthy; fracture flat conchoidal.

Opaque; does not adhere to the tongue.

Hardness 2·75; specific gravity 2·342.

Before the blowpipe per se it blackens, but does not become magnetic; nor can it be fused. With carbonate of soda it does not readily combine. Neither does it fuse with borax or biphosphate of soda.

Its constituents, by my analysis, are,

		Atoms.	
Silica,	30·88	15·44	20·86
Alumina,	20·76	9·22	12·46
Peroxide of iron,	26·16	5·23	7·06
Lime,	2·60	0·74	1
Water,	19·60	17·42	23·54
	100		

These atomic numbers correspond with

12·46 atoms silicate of alumina,
7·06 atoms silicate of iron,
1 atom silicate of lime,
23·54 atoms water.

Or, if we consider the silicates of iron and lime to be previously united, the constitution of the mineral will be

3 atoms silicate of alumina,
2 atoms silicate of iron and lime,
6 atoms water,

And the formula $3AlS+2(\frac{7}{8}f+\frac{1}{8}Cal)S+6Aq$.

Sp. 9. *Bonsdorfite.*

I give this name to a mineral described and analyzed by

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* From πλίνθος, *a brick.*

Bonsdorf.* It occurs in a red granite at Biskopsokern, near Obo, in Finland. It is accompanied by a black grey dichroite, and a greenish coloured mineral, which Bonsdorf considers as a soda spodumene.

Colour greenish brown, or dark olive green. When viewed by transmitted light, thin lamellæ may be perceived of a light greenish colour.

Occurs crystallized in regular six-sided prisms. In general the lateral edges of the prism are replaced by so many planes that the prism assumes nearly the appearance of a cylinder.

Texture foliated; folia perpendicular to the axis of the prism; cross fracture conchoidal.

Lustre of the faces like that of talc, of the cross fracture waxy.

Translucent when in thin plates; when in thick pieces opaque.

Hardness 3·5; specific gravity not given.

Its constituents, as determined by Bonsdorf's analysis, are,

		Atoms.	
Silica, ...	45·05	22·52	19·24
Alumina, ...	30·05	13·35	11·41
Magnesia with trace of oxide of manganese,	9·00	3·6	3·07
Protoxide of iron, . .	5·30	1·16	1
Water, ...	10·60	9·42	8·05
	100·		

These atomic numbers correspond with

$11\frac{1}{2}$ atoms silicate of alumina,
3 atoms bisilicate of magnesia,
1 atom bisilicate of iron,
8 atoms water;

Or, considering the bisilicates of magnesia and iron as previously combined, the constitution will be

3 atoms silicate of alumina,
1 atom bisilicate of magnesia and iron,
2 atoms water.

The formula is $3AlS+(\frac{3}{4}Mg+\frac{1}{4}f)S^2+2Aq$.

Sp. 10. *Chalilite.*

This mineral occurs in the Donegore mountains, near

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* Kong. Vet. Acad. Handl., 1827, p. 15.

Sandy Brae, in the County of Antrim, and was brought me by Mr. Doran.

Colour deep reddish brown.

Texture compact; fracture splintery and flat conchoidal; has a considerable resemblance to flint in its appearance. Hence the name.[*]

Lustre between vitreous and resinous.

Translucent on the edges.

Hardness 4·5; specific gravity 2·252.

Before the blowpipe becomes white, and spreads out like a cauliflower. With carbonate of soda it effervesces, and melts with some difficulty into a white bead with a pearly lustre. With borax it fuses into a colourless glass.

When heated it gives out 16·66 per cent. of water. Its constituents are

		Atoms.	
Silica, . .	36·56	18·28	19·76
Alumina, . .	26·20	11·82	12·77
Lime, . .	10·28	2·93	3·16
Peroxide of iron,	9·28	1·85	2
Soda, . .	2·72	0·68	0·75
Water, . .	16·66	14·81	16
	102·10		

It is obvious that the constituents are in the state of simple silicates. If we admit that the silicates of alumina and iron were previously united, as also those of lime and soda, the constitution of chalilite will be as follows:—

4 atoms silicate of alumina and iron,
1 atom silicate of lime and soda,
4 atoms water.

The formula is $4(\frac{7}{8}\text{Al}+\frac{1}{8}\text{f})\text{S}+(\frac{4}{5}\text{Cal}\frac{1}{5}\text{N})\text{S}+4\text{Aq}$.

Sp. 11. *Karpholite.*

This mineral has been hitherto found only at Schlaggenwald in Bohemia, in granite. It was examined and named by Werner, a very short time before his death.

Colour a high straw yellow. Hence the name, which signifies *strawstone*.[†]

It consists of minute crystals diverging from a point, so as to have the appearance of tufts.

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[*] From *χαλιξ*, a flint.

[†] From *καρφος*, *straw*.

Lustre silky, glistening; opaque.

Hardness 2·5; but it is not easily determined, on account of the ease with which the little crystalline threads may be separated from one another. Specific gravity, according to Breithaupt, 2·935; according to Steinmann, 2·923; according to Stromeyer, 2·9365.

It intumesces before the blowpipe, becomes white, and melts imperfectly into a coherent mass. With carbonate of soda it melts into a green enamel. Muriatic acid has scarcely any action in it.

Its constituents, as determined by Stromeyer*, are

		Atoms.
Silica, . .	36·154 .	18·07
Alumina, . .	28·669 .	11·85
Protoxide of mangan.,	19·160 .	4·25
Protoxide of iron,	2·290 .	0·50
Lime, . .	0·271 .	0·07
Fluoric acid, .	1·470 .	1·17
Water, . .	10·780 .	9·58
	98·794	

If we admit the fluoric acid to be combined with lime and alumina, and to be accidental, the mineral will consist of

7 atoms silicate of alumina,
3 atoms sesquisilicate of manganese and iron.
6 atoms water.

The formula will be $7AlS+3(\frac{17}{19}mn+\frac{2}{19}f)S^{1\frac{1}{2}}+6Aq$.

Sp. 12. *Antrimolite.*†

This mineral was first observed by Patrick Doran, an Irish mineral dealer, on the sea-shore at Bengane, about four miles east from the Giant's Causeway, on the north coast of the county of Antrim.

It consists of stalactitical looking masses about the length and thickness of a finger, adhering to the summit of cavities in an amygdaloidal rock. In the centre of each stalactite is a crystal of calcareous spar, or a fibrous looking round mass, pretty long, and having a foliated structure and a brown colour, and consisting of calcareous spar.

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* Untersuchungen, p. 410. Professor Steinmann had previously analyzed it with nearly the same result, except that he did not recognise the presence of fluoric acid. See Schweigger's Jour. xxv. 413.

† From the County of Antrim in Ireland, where alone this mineral has been hitherto found.

Colour chalk-white.

Texture fine silky fibrous. The fibres diverging from the centre nucleus like radii from a centre.

Opaque; dull.

Hardness 3·75; specific gravity 2·0964.

When heated it gives out water, which reddens vegetable blues and contains muriatic acid. The quantity driven off amounts to 15·42 per cent.

Before the blowpipe it does not froth, but softens into an enamel. With biphosphate of soda it dissolves very slowly into a transparent colourless glass.

Dissolves readily in muriatic acid and gelatinizes.

Its constituents, by my analysis, were as follow:

		Atoms.
Silica,	43·47	21·73
Alumina,	30·26	13·44
Lime,	7·50	2·14
Potash,	4·10	0·68
Protoxide of iron,	0·19	0·04
Chlorine,	0·098	0·02
Water,	15·32	13·61
	100·938	

As the chlorine is driven off by heat, it is probably in the mineral combined with protoxide of iron, constituting dichloride of iron. The atoms of silica being 21·73, while those of the bases amount only to 16·26; it is obvious that some of the bases must be in the state of bisilicates or tersilicates.

We may consider the constitution of antrimolite to be

20 atoms silicate of alumina,
3 atoms tersilicate of lime,
1 atom tersilicate of potash,
20 atoms water.

Or, admitting the tersilicates of lime and potash to be previously united,

5 atoms silicate of alumina,
1 atom tersilicates of lime and potash,
5 atoms water.

The formula is $5AlS+(\frac{3}{4}Cal+\frac{1}{4}K)S^3+5Aq$.

Sp. 13. *Glottallite.*[*]

I received the mineral to which I gave this name, from a dealer in minerals at Old Kilpatrick, about eight miles from Glasgow, on the banks of the Clyde. He found it, I have reason to believe, in the hills behind Port Glasgow; though of this I am not quite certain, as I have never been able to procure a second specimen. It coats one side of a fragment of greenstone.

Colour white.

Composed of crystals so mixed together, that only a small portion of each can be seen. They seem to be regular octahedrons; at least four-sided pyramids, the faces of which appeared to be equilateral triangles, are visible. Others of the crystals seem to be cubic.

Lustre vitreous; strongly translucent; brittle.

Hardness 3·5; specific gravity 2·181.

Before the blowpipe swells up and melts into a white enamel. With carbonate of soda it fuses into an opaque white bead. With borax into a translucent glass.

When heated in a glass tube it gives out 21¼ per cent. of pure water.

Its constituents, by my analysis, are

		Atoms.	
Silica,	37·014	18·51	2·71
Lime,	23·927	6·83	1
Alumina,	16·308	7·27	1·06
Peroxide of iron,	0·500	0·10	0·01
Water,	21·250	18·88	2·76
	98·999		

These atomic numbers approach pretty nearly

1 atom silicate of lime,
1 atom sesquisilicate of alumina,
2¾ atoms water.

The formula is $\mathrm{CalS}+\mathrm{AlS}^{1\frac{1}{2}}+2\frac{3}{4}\mathrm{Aq}$.

Sp. 14. *Harringtonite.*

The mineral to which I have given this name, was brought me by Mr. Doran from the north of Ireland. It constitutes a vein about 0·6 inch thick in an amygdaloidal rock.

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[*] From *Glotta*, the river Clyde.

Colour snow-white; texture compact and earthy; lustre like that of the almond; opaque; very tough.

Hardness 5·25; specific gravity 2·217.

It was subjected to two successive analyses. The results were as follow:

			Atoms.
Silica,	44·960	44·840	22·42
Alumina,	26·848	28·484	12·66
Lime,	11·008	10·684	3·05
Protoxide of iron,	0·880	trace	—
Soda,	5·560	5·560	1·39
Water, with trace of mur. acid,	10·280	10·280	9·13
	99·540	99·848	

Of these analyses the second is the most accurate, being made upon a specimen selected with much care.

The atomic numbers agree very nearly with the following constitution:

3 atoms sesquisilicate of alumina,
1 atom silicate of lime and soda,
2 atoms water.

The formula is $3AlS^{1\frac{1}{2}}+(\frac{2}{3}Cal+\frac{1}{3}N)S+2Aq$.

Sp. 15. *Soapstone.*

Steatite in part.

The term *steatite* has been applied so loosely by mineralogists, that it includes minerals composed of very different ingredients and belonging in reality to different species. I confine the term *soapstone* to the mineral which occurs in the peninsula of the Lizard, partly in a vein in serpentine at the Lizard Point, and partly near the Mullyan churchtown.

Colour greenish white, sometimes with a tinge of yellow, and mottled with green and red; the white portion often traverses the red in a kind of irregular vein. When first extracted from the vein it may be kneaded like dough, but when left exposed to the air, it loses part of its moisture, becomes translucent on the edge, but still continues soft enough to be scratched by the nail.

Texture fine earthy.

Feel unctuous; lustre soapy; sectile.

Specific gravity of the reddish variety 2·411; of the white variety 2·396.

Not fusible per se before the blowpipe.

Employed in the manufacture of porcelain at Swansea.

Klaproth informs us that it was used for the same purpose at Worcester.

Breaks into a fine powder, which does not feel gritty between the teeth.

Its constituents are as follow:

Silica,	45	42·320	43·884
Magnesia,	24·75	25·680	24·144
Alumina,	9·25	9·384	9·872
Lime,	—	4·680	—
Protox. of iron,	1	1·083	—
Potash,	0·75	—	—
Water,	18·00	16·960	21·228
	98·75*	100·107†	99·128

These analyses approach each other pretty nearly. It is clear that the lime, protoxide of iron, and potash, are accidental ingredients. The mean of the three gives us

		Atoms.	
Silica,	43·734	21·86	5·18
Magnesia,	24·858	9·94	2·35
Alumina,	9·502	4·22	1
Water,	18·729	16·64	3·94

It is obvious that the bases are in the state of sesquisilicates. The atomic numbers approach very nearly

$2\frac{1}{3}$ atoms sesquisilicate of magnesia,
1 atom sesquisilicate of alumina,
4 atoms water.

The formula is $2\frac{1}{3}MgS^{1\frac{1}{2}}+AlS^{1\frac{1}{2}}4Aq$.

Sp. 16. *Killinite.*

This mineral was discovered by Dr. Taylor in coarse granite veins which traverse a fine grained granite at Killiney, Dublin bay. The veins contain also a good deal of spodumene. It was described, and an imperfect analysis of it was published by Dr. Taylor and Dr. Barker.

Colour brownish yellow, sometimes with a tinge of green. Sometimes the colour is green, but this is comparatively rare. Some specimens when heated to redness become snow-white, while others assume a reddish tinge, indicating a difference in purity.

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* Klaproth, Beitrage, v. 22.

† By my analysis. The first specimen was mottled red and white; the second was pure white. Both had been in my cabinet for at least 15 years.

Texture foliated. Sometimes in crystals. The shape is a four-sided prism, apparently rectangular; but no specimen that I have seen admits of measurement. I have a crystal of it four inches long, 1·3 inch broad, and 0·9 inch thick.

Lustre waxy; dull, except from occasional admixture of foreign matter, which may give it a glimmering lustre.

Opaque, or only slightly translucent on the edges; streak yellowish white.

Hardness 3·5; specific gravity, 2·711.

Before the blowpipe becomes white and friable, and fuses slowly into a white opaque bead, but not nearly so easily as spodumene. With carbonate of soda fuses into a transparent glass. With borax and with biphosphate of soda it fuses into a colourless glass, leaving a silica skeleton.

Two analyses of it were made in my laboratory, the first by Captain Lehunt, the second by Mr. Blythe. The result is as follows:

	*	†
Silica,	49·08	47·925
Alumina,	30·60	31·041
Potash,	6·72	6·063
Protoxide of iron,	2·27	2·328
Lime,	0·68	0·724
Magnesia with manganese,	1·08	0·459
Protoxide of manganese,	—	1·255
Water,	10·00	10·000
	100·43	99·975

These analyses approach each other very closely. The mean is as follows:

		Atoms.	
Silica,	48·50	24·25	23·31
Alumina,	30·82	13·70	13·17
Potash,	6·39	1·06	1·01
Protoxide of iron,	2·30	0·51	0·5
Water,	10·00	8·88	8·5

These atomic numbers give us the constitution of killinite as follows:

13 atoms sesquisilicate of alumina,
1 atom bisilicate of potash,
½ atom bisilicate of iron,
8½ atoms water;

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* By Captain Lehunt. † By Mr. Blythe.

Or, admitting the bisilicates of potash and iron to be previously combined,

9 atoms sesquisilicate of alumina,
1 atom bisilicate of potash and iron,
4 atoms water.

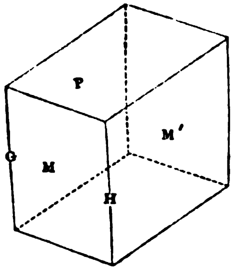
The formula is $9AlS^{1\frac{1}{2}}+(\frac{1}{3}K+\frac{2}{3}f)S^2+4Aq$.

Sp. 17. *Lomonite.*[*]

Efflorescing zeolite.

· This mineral was discovered in 1785, by M. Gillet Laumont, in the mine of Huelgoët, in Brittany. It is found also in the amygdaloidal rocks in the Kilpatrick hills, near Glasgow.

Colour white, usually with a shade of red, yellow, or green; streak white.



Occurs most commonly in crystals. The primary form is an oblique rhombic prism.

P on M or M′ 113° 30′
M on M′ 86° 15′

The edge H (and sometimes also the edge G) is frequently replaced by a tangent plane. The base P is commonly replaced by two low faces.

Lustre vitreous, inclining to pearly upon the more distinct faces of cleavage; translucent.

Hardness 3·5, but when the mineral is exposed to the air it loses its water, and falls into powder.

Specific gravity, as determined by Hauy, 2·3.

Before the blowpipe it fuses into a white spumous mass. It gelatinizes in acids, and acquires negative electricity by friction, if insulated.

We have two analyses of this mineral, one by M. L. Gmelin, and another by M. Vogel. The following table exhibits the results which they obtained :[*]

			Mean.	Atoms.
Silica,	48·3	49	48·65	24·32
Alumina,	22·7	22	22·35	9·93
Lime,	12·1	9	10·55	3·01
Water,	16·0	17·5	16·75	14·88
Carbonic acid,	—	2·5		
	99·1	100		

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[*] Named from the discoverer.

[†] Mohs' Mineralogy, ii. 235.

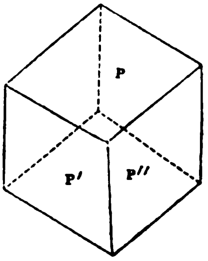
Its constitution is obviously

3 atoms bisilicate of alumina,
1 atom bisilicate of lime,
5 atoms water.

The formula is $3AlS^2+CalS^2+5Aq$.

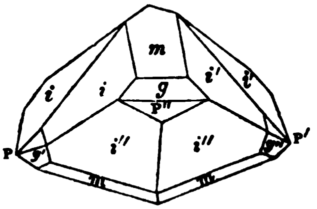
Sp. 18. *Chabazite.*[*]

This mineral was first named and described by Box d'Antic in a memoir read to the Natural History Society of Paris, about the year 1780. It occurs pretty commonly in trap rocks. Thus it is abundant at Talisker, in the Isle of Skye, and at Kilmalcolm, in Renfrewshire. It is to be found also at the Giants' Causeway, and in many other places. The first crystallized specimens were observed at Oberstein, in Germany.



Colour white; streak white.

Always crystallized. Primary form an obtuse rhomboid, P on P′ 94° 46′. This is the common form which it has in the neighbourhood of Glasgow. But at Oberstein, in Saxony, and in the north of Ireland it occurs in the form figured in the margin.[†]



P on *g′*, P″ on *g* or P″ on *g′*,	120° 5′
P on *i*,	175° 30′
P′ on *i′*,	
P″ on *i″*	
i on *i*	173° 32′
i′ on *i″*	
i″ on *i′*	
g on *m*	143° 59′

Cleaves pretty easily, and yields the primary crystal, often with brilliant faces.

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[*] The name chabazite was taken by Box d'Antic, from the Greek word χαβαζιος. This word occurs in the poem περι λιθων, ascribed to Orpheus. In this poem 20 species of stones are celebrated for their virtues and uses, but without the least attempt to describe them. Hence it is impossible to discover the minerals to which the Greek names were applied. The last of the twenty is χαβαζιος. The praises of this stone occupy 17 lines of the poem. Its cooling virtues, and its power of curing the bite or sting of the scorpion are celebrated.

[†] According to Sir David Brewster the primary form of this mineral is not a rhomboid, but a prism.

Fracture uneven; brittle.

Lustre vitreous.

Transparent to translucent.

Hardness 3·75; specific gravity of transparent rhomboids from Kilmalcolm 2·088; Haidinger states it at 2·100. Captain Lehunt found that of an Irish specimen analyzed by him (containing much soda) 2·472. Hauy makes the specific gravity 2·7176.

Before the blowpipe melts into a white spumous mass.

Easily soluble in muriatic acid.

The following table exhibits the constituents of transparent rhomboidal chabasites:

	*	†	‡	Mean.	Atoms.
Silica, .	48·756	50·65	48·30	49·202	24·6
Alumina, .	17·440	17·00	19·28	17·91	7·96
Lime, .	10·468	9·73	8·72	9·639	2·75
Potash, .	1·548	1·70	2·50	1·916	0·32
Water, .	21·720	19·50	20·00	20·41	18·14
	99·932	98·58	98·78		

The constitution seems to be

3 atoms bisilicate of alumina,
1 atom tersilicate of lime,
6 atoms water.

The formula is $3AlS^2+CalS^3+6Aq$.

But there is another variety of chabasite in which soda replaces a considerable portion of the lime. It is remarkable that this chabasite is always crystallized in the peculiar form figured in page 333. The following table exhibits the constituents of two specimens of this kind analyzed by Captain Lehunt, in my laboratory, and another by Berzelius:

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* By my analysis. The specimen was from Kilmalcolm, Renfrewshire, in transparent colourless crystals.

† Berzelius, Afhandlingar, vi. 190. The specimen was from Gustafsberg, in crystals, and selected with great care.

‡ Arfvedson, Kong. Vet. Acad. Handl., 1824, p. 356. The specimen was from the Faroe Isles. The specimen was given to Berzelius by Hauy as an example of pure chabasite.

	*	†	‡
Silica,	48·988	49·17	46·184
Alumina,	19·774	18·90	18·423
Soda,	6·066	12·19	5·967
Lime,	4·068	—	7·029
Protoxide of iron,	0·404	—	0·397
Water,	20·700	19·73	22
	100	99·99	100

The specimen analyzed by Berzelius containing no lime, but only soda and alumina, ought to constitute a new species, but unfortunately we have no description of it.

Its constituents were

		Atoms
Silica,	24·58	8·06
Alumina,	8·40	2·75
Soda,	3·05	1
Water,	17·53	5·74

This corresponds nearly with

3 atoms bisilicate of alumina,
1 atom tersilicate of soda,
6 atoms water.

There is a slight deficiency of bisilicate of alumina.

The specimens analyzed by Captain Lehunt were mixtures or combinations of the common calcareous-chabasite and the soda-chabasite of Berzelius.

Sp. 19. *Levyine.*

This mineral was first noticed by Mr. Heuland, in the cavities of an amygdaloidal rock from Dalsnypen, in Faroe, where it is accompanied by chabasite, analcime, and a new variety of heulandite. He sent specimens of it to Dr. Brewster, who determined its optical properties, and distinguished it by the name of levyite.

Colour white; streak white.

It occurs only crystallized. The primary form, according to Haidinger, is an obtuse rhomboid. But the shape of the only crystalline form hitherto observed, is that in the margin, obviously consisting of two crystals penetrating each other.

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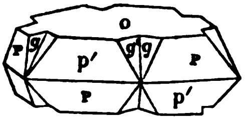
* Captain Lehunt. The specimen was from the North of Ireland. Colour yellow.

† Berzelius. He says that the specimen was from Scotland. Kong. Vet. Acad. Handl., 1825, p. 358.

‡ Captain Lehunt. The specimen was white, and also from the County of Antrim.

§ Named in honour of Mr. Levy.



O on *g* 136° 1′
O on P 117° 24′

Fracture imperfect conchoidal; brittle.

Lustre vitreous; semitransparent.

Hardness 4; specific gravity by my trial, 2·161.

Insoluble in acids, and does not gelatinize with them.

Before the blowpipe intumesces and whitens. With biphosphate of soda it yields a transparent globule, which contains a skeleton of silica, and becomes opaque on cooling.

The following table exhibits the constituents of this mineral according to the analyses hitherto made:

	*	†
Silica, .	48	44·75
Alumina,	20	20·333
Lime, .	8·35	8·833
Magnesia,	0·40	0·770
Potash, .	0·41	—
Soda, .	2·75	3·333
Water, .	19·30	20
	99·21	98·019

It has been supposed by Dr. Brewster and Mr. G. Rose, that Berzelius had analyzed a chabasite instead of a levyine, but my result (except in the silica) approaches so near his, as to render that supposition unlikely. The mean of the two analyses is

		Atoms.	
Silica,	46·37	23·18	8·64
Alumina,	20·16	8·96	3·34
Lime,	8·59	2·45	1
Magnesia,	0·58	0·23	
Soda, .	3·17	0·79	0·29
Water,	19·65	17·46	6·5

---

* Berzelius, Kong. Vet. Acad. Handl., 1824, p. 356. The specimen was sent by Dr. Brewster for analysis. It came from Mr. Heuland, who had it from the Faroe Islands.

† By my analysis. I had the specimen from Mr. Doran, an Irish mineral dealer. The soda contained a trace of potash.

If we admit the soda to be accidental, the bases are in the state of bisilicates, and the constitution is

$3\frac{1}{3}$ atoms bisilicate of alumina,
1 atom bisilicate of lime and magnesia,
$6\frac{1}{2}$ atoms water.

Thus it contains less silica and more water than chabasite. The formula will be

$$3\tfrac{1}{3}\,AlS^2+(\tfrac{10}{11}Cal+\tfrac{1}{11}Mg)S^2+6\tfrac{1}{2}Aq.$$

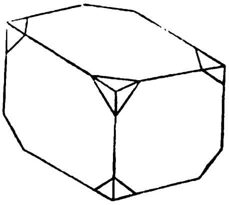
This difference in the constitution of levyine and chabasite, though not great, yet, if it be constant, will be sufficient to constitute a specific difference between the two minerals.

Sp. 20. *Analcime.**

Cubizite, sarcolite.

This mineral seems to have been first particularly noticed by Dolomieu, but Hauy constituted it a peculiar species. It occurs usually in cavities in amygdaloid and basalt, and is abundant in the Kilpatrick hills, near Glasgow. It is said also to have been found in small veins in some of the older rocks.

Colour white passing into grey; often reddish-white or flesh-red; streak white.



It occurs in nodules in aggregated crystals, in the form of minute diverging fibres, or in cubic crystals, either complete or having their solid angles replaced each by three planes, as represented in the margin. When these planes increase so much as to conceal the primary faces, a twenty-four-sided crystal is formed, of which a figure is given in page 286. It is known by the name of the leucite crystal, and consists of twenty-four equal and similar trapezoidal faces. This is by far the most usual crystal in the analcime of the Kilpatrick hills.

Fracture imperfect conchoidal.

Lustre vitreous; brittle.

Sometimes nearly transparent. This is the case with the analcime crystals which occur at the Giant's Causeway. Most commonly it is only translucent. Sometimes it puts on the appearance of an enamel, and is only very slightly translucent. The lustre then is waxy.

---

* From α privative, and αλκος, *strength*; named from its very weak electric virtue.

Hardness 6·25; specific gravity of a transparent specimen from the Giant's Causeway 2·278; Haidinger states the specific gravity at 2·068.

On charcoal it melts without intumescence or ebullition, into a clear glassy globule; gelatinizes in muriatic acid.

Its constituents are as follow:

	[*]	[†]	Mean.	Atoms.	
Silica, . .	55·12	55·60	55·36	27·68	7·8
Alumina, .	22·99	23·00	22·999	10·22	2·88
Soda, . .	13·53	14·65	14·19	3·65	1
Water, . .	8·27	7·90	8·08	7·18	2·02
	99·91	101·15			

These two analyses almost coincide. They give us the constitution of analcime as follows:

3 atoms bisilicate of alumina,
1 atom bisilicate of soda,
2 atoms water.

The formula is $3AlS^2+NS^2+2Aq$.

Sp. 21. *Lehuntite.*[‡]

Compact zeolite.

I give this name to a species of zeolite which occurs at Glen Arm, a precipice on the east coast of the County of Antrim, in an amygdaloidal rock.

Colour flesh-red.

Appears to the naked eye like a lump of sugar. Under the microscope it appears to be composed of minute scales.

The mass, when broken in two, exhibits the appearance of five distinct layers, three of them flesh-red, and two of them white lines separating the flesh-red portion into three portions. Or it may be described as a flesh-red mass, with two parallel white lines near the centre.

Translucent on the edges.

Hardness 3·75; specific gravity 1·958.

Before the blowpipe fuses into a white enamel. With carbonate of soda it melts easily into a white enamel. With borax or biphosphate of soda it forms a transparent bead with a silica skeleton, which becomes opaque on cooling.

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[*] M. H. Rose, Poggendorf's Annalen, xii. 181.

[†] By my analysis. The specimen was from the Giant's Causeway.

[‡] In honour of Captain Lehunt.

Its constituents, by the analysis of my nephew, Dr. R. D. Thomson, are:

			Atoms.
Silica,	47·33	23·66	6·34
Alumina,	24·00	10·66	2·85
Soda,	13·20	3·3	1
Lime,	1·524	0·43	
Water,	13·60	12·08	3·23
	99·654		

If we allow for a small deficiency of silica, the constitution of Lehuntite is

3 atoms bisilicate of alumina,
1 atom bisilicate of soda and lime,
3 atoms water.

The formula is $3AlS^2+(\frac{8}{9}N+\frac{1}{9}Cal)S^2+3Aq$.

Sp. 22. *Cluthalite.*[*]

This mineral is found in the western part of the Kilpatrick hills, near Dumbarton, and is named from the valley of the Clyde, which the locality borders on. It forms large nodules in amygdaloid.

Colour flesh-red.

Constitutes a congeries of imperfect crystals, with rough surfaces. To the eye they seem to be right rectangular prisms.

Opaque, or only translucent on the edges.

Lustre vitreous; brittle; easily frangible.

Hardness 3·5; specific gravity 2·166.

Its constituents, by my analysis, are:

			Atoms.
Silica,	51·266	25·63	9·35
Alumina,	23·560	10·47	3·82
Peroxide of iron,	7·306	1·46	1
Soda,	5·130	1·28	
Magnesia,	1·233	0·50	0·18
Water,	10·553	9·38	3·42
	99·048		

---

[*] From *Clutha*, a name by which the valley of the Clyde has been sometimes distinguished.

If we allow for a slight deficiency of silica, the bases are in the state of bisilicates. If the bisilicates of iron and soda were previously combined, and those of alumina and magnesia, the constitution of cluthalite will be

4 atoms bisilicate of alumina and magnesia,
1 atom bisilicate of iron and soda,
3 atoms water.

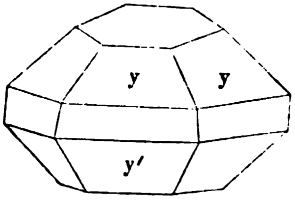
The formula is $4(\frac{19}{20}\text{Al}+\frac{1}{20}\text{Mg})\text{S}^2+(\frac{1}{2}\text{N}+\frac{1}{2}\text{f})\text{S}^2+3\text{Aq}$.

Sp. 23. *Hydrolite.*[*]

Gmelenite, sarcolite of Vauquelin.

This mineral was first observed by Leman, in the Vicentine, in cavities of amygdaloidal rocks. More lately it was observed by the late Mr. Thomas Allan, of Edinburgh, in the little deer park of Glen Arm, County of Antrim, Ireland. It has been since found in amygdaloidal rocks, in Antrim, by Mr. Doran, an Irish mineral dealer, from whom most of the Irish specimens of hydrolite have been obtained.

Colour snow-white; always crystallized. The only crystal which I have seen is that figured on the margin, a double six-sided pyramid with the apices truncated. Between the pyramids is interposed a short six-sided prism. The faces of the pyramids are all streaked parallel to the base y on y′ according to Dr. Brewster's measurement 83° 36′. It seems, from the observations of Haidinger, to be closely related to the crystalline form of the chabasite.



Translucent; very frangible.

Hardness 4; specific gravity 2·054.

Before the blowpipe increases in bulk, and assumes the appearance of an enamel, but does not melt into a glass.

When ignited it gives out pure water, and loses 29·866 per cent. of its weight.

Its constituents, determined by my analysis, are as follow:

---

[*] From ὕδωρ, *water*, and λίθος, *a stone*. Because it contains so great a proportion of water.

		Atoms.	
Silica,	39·896	19·94	13·3
Alumina,	12·968	5·76	3·82
Peroxide of iron,	8·270	1·65	1·1
Potash,	9·000	1·50	1
Water,	29·866	26·54	17·7
	100·000*		

These numbers approach very nearly

4 atoms tersilicate of alumina,
1 atom silicate of iron,
1 atom silicate of potash,
18 atoms water.

Or, if we suppose the silicates of potash and iron previously combined,

2 atoms tersilicate of alumina,
1 atom silicate of iron and potash,
9 atoms water.

The formula is $3AlS^3+({}^1f+\frac{1}{2}K)S+9Aq$.

Sp. 24. *Erinite.*†

This mineral occurs in an amygdaloidal rock in the county of Antrim, about four miles east from the Giant's Causeway. It was found by Mr. Doran, from whom I obtained the specimen which I subjected to analysis.

Colour yellowish-red.

Compact; very fine grained.

Fracture small conchoidal.

Opaque; lustre resinous; feel soapy.

Hardness 1·75; specific gravity 2·04.

When heated gives out about the fourth of its weight of water.

Before the blowpipe whitens, but does not fuse; with carbonate of soda fuses with effervescence into a blebby glass; with borax it fuses into a transparent colourless glass; with biphosphate of soda into an opaque white frit.

Its constituents were found to be

---

* The analysis was made on 5·3 grains. The loss sustained was 1·987 per cent. But I had every reason to believe that this loss was wholly potash. I have therefore added it to the amount of potash in the table. I actually obtained only 7·013 per cent. of potash.

† From *Erin*, the name by which Ireland is known in the native language of the country.

		Atoms.	
Silica,	47·036	23·52	16·68
Alumina,	18·464	8·2	5·8
Lime,	1·000	0·28	0·2
Protoxide of iron,	6·360	1·41	1
Magnesia,	trace	—	—
Water,	25·280	22·47	15·9
Common salt,	0·900		
	99·04		

The common salt was doubtless derived from the sea, to the spray of which the rock containing the erinite was exposed.

If we unite the lime to the alumina, the atoms of this last will be just six times as many as those of iron. The constitution of the mineral (admitting a slight excess of silica) is

6 atoms bisilicate of alumina,
1 atom quatersilicate of iron,
16 atoms water.

The formula is $6AlS^2+fS^4+16Aq$.

Sp. 25. *Pyrophyllite.*[*]

This mineral comes from the Uralian mountains, and was distinguished by the name of *fibrous talc*. But its behaviour under the blowpipe is quite different from that of talc. When heated per se it spreads out in a fan-like shape, and increases to twenty times its former bulk. The matter thus swollen is infusible. With carbonate of soda it fuses into a clear yellow glass; with biphosphate of soda it fuses into a colourless glass, leaving a silica skeleton. When heated with nitrate of cobalt it assumes a fine blue colour.

Colour white; lustre pearly.

Amorphous; texture radiated, with an indistinct rectangular cleavage.

Its constituents, as determined by M. Hermann, of Moscow,[†] are

		Atoms.
Silica,	59·79	29·89
Alumina,	29·46	13
Magnesia,	4·00	1·6
Peroxide of iron,	1·80	0·36
Water,	5·62	5
	100·67	

From πυρ, *fire*, and φυλλον, *a leaf.*

[†] Poggendorf's Annalen, xv. 592.

These numbers correspond with

8 atoms bisilicate of alumina,
1 atom bisilicate of magnesia,
0·2 atom bisilicate of iron,
3 atoms water.

If we admit the bisilicate of iron to be accidental, the formula will be $8AlS^2+MgS^2+3Aq$.

Sp. 26. *Agalmatolite.*

Bildstein, figurestone, koreite, lardite, pagodite.

This mineral is brought from China in the form of pagodas, or chimney-piece ornaments. It is found also at Nagyag, in Transylvania, as was first observed by Klaproth.

Colour white, with a shade of grey, green, yellow, red, or brown.

Massive, and sometimes imperfectly slaty.

Fracture coarse splintery; lustre waxy, and nearly dull; acquires some lustre in the streak.

Translucent, in most cases only on the edges; sectile.

Hardness 2; specific gravity, as determined by Klaproth, 2·815. I found it 2·895.

Infusible before the blowpipe, but becomes white.

Partly soluble in sulphuric acid, leaving a residue of silica.

Klaproth, in his first analysis, did not discover potash in the Chinese variety, but it was found by Vauquelin. This induced Klaproth, who had detected potash in the Nagyag variety, to repeat his analysis of the Chinese, when he found potash in it also.

The following table exhibits the constituents of this mineral, according to the best analyses hitherto made:

	*	†	†	‡	‡	§
Silica, . . .	56	54·5	55	55	51·5	49·816
Alumina, . . .	29	34	33	30	32·5	29·596
Lime, . . .	2	—	—	1·75	3·9	6·000
Protoxide of iron, .	1	0·75	0·5	1	1·75	1·500
Protoxide of manganese,	—	—	—	trace	1·2	—
Potash, . . .	7	6·25	7	6·25	6·0	6·800
Water, . . .	5	4	3	5·5	5·13	5·5
	100	99·5	98·5	99·5	101·08	99·212

* Vauquelin, Ann. de Chim. xlix. 83.

† Klaproth, Beitrage, v. 19. The first specimen was from Nagyag, the second from China.

‡ John, Annals of Philosophy, iv. 214. Both specimens were from China; the first was yellow, the second red.

§ By my analysis. The specimen was from China.

The lime, protoxides of iron and manganese vary so much in the different analyses, that we must consider them as accidental. The mean of the analyses gives the other constituents

		Atoms.
Silica,	54·3	27·15
Alumina,	31·35	13·93
Potash,	6·55	1·09
Water,	4·71	4·18

This corresponds with

13 atoms bisilicate of alumina,
1 atom silicate of potash,
4 atoms water.

The formula is $13AlS^2 + KS + 4Aq$.

Sp. 27. *Stilbite.*[*]

Foliated zeolite of Werner, in part. Desmine.

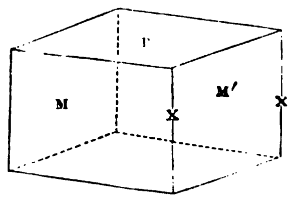
This mineral occurs abundantly in the amygdaloidal rocks of the Kilpatrick hills, near Glasgow. It abounds also at Talisker, Isle of Skye, and in many other places.

Colour white, most commonly with a shade of yellow, red, or brown. Beautiful specimens of it of a flesh-red colour are common in the Kilpatrick hills, especially near Dumbarton, and at Carberry, in the Stockymuir. Streak white.

It is most commonly crystallized in slender prisms, which are fasciculated in a sheaf-like form. The primary form is generally considered to be a right prism, with rectangular bases; but as there is no cleavage parallel to the lateral planes of such a prism, but in some crystals indications of a cleavage parallel to the planes of a rhombic prism, Mr. Brooke has been led to consider the primary form as a right rhombic prism, in which

M on M′ 101° 36′

The edges x are often replaced by planes, and the prism most commonly terminates in a four-sided pyramid, sometimes complete, but most commonly truncated, leaving a small face parallel to the face P of the primary form.



Lustre vitreous, that of the lateral faces of the prism pearly; brittle.

Semitransparent to translucent.

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[*] From στιλϐω, *to shine*, on account of its great lustre.

Hardness 3·5; specific gravity, by my trials, from 2·133 to 2·143. Haidinger states it at 2·161; Dumenil at 2·14.

Does not gelatinize with acids.

Before the blowpipe yields an opaque vesicular bead.

The constituents of this mineral are as follow:

	*	†	‡	§	||
Silica, .	58	52·25	55·615	52·50	54·805
Alumina, .	16·1	18·75	16·681	17·318	18·205
Lime, .	9·2	7·36	8·170	11·520	9·830
Soda, .	—	2·39	1·536	—	—
Water, .	16·4	18·75	19·300	18·450	19·000
	99·7	99·50	101·302	99·788	101·84

The mean of all these analyses, reckoning the soda, where it occurs along with the lime, is as follows:

			Atoms.	Omitting the soda.
Silica, .	54·67 .	27·33 .	9·7 .	10·5
Alumina,	17·41 .	7·73 .	2·74 .	3
Lime, .	9·91 .	2·82 .	1 .	1
Water, .	18·4 .	16·35 .	5·8 .	6·28

These numbers approach pretty nearly to

3 atoms tersilicate of alumina,
1 atom tersilicate of lime,
6 atoms water.

If we leave out the soda as accidental, the atoms of alumina are almost exactly thrice as many as those of lime. But there is a deficiency of silica; it should be 12 atoms, while it is only 10½. However, in Hisinger's analysis, it amounts to 11·15 atoms, so that the deficiency in that case is less than an atom.¶

The formula is $3AlS^3+CalS^3+6Aq$.

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* Hisinger, Afhandlingar, iv. 357.

† Dumenil, Schweigger's Jahrbuch, vi. 163.

‡ Gehlen, Schweigger's Jour. viii. 355.

§ By my analysis. A red stilbite from the neighbourhood of Dumbarton.

|| By my analysis. A white stilbite.

¶ Stilbite frequently occurs in states not easily recognised by its external characters. My friend, Mr. Andrews, of Belfast, whose knowledge of practical chemistry enables him to analyze minerals with great precision, met with a large mass of matter at the Cave hill, near Belfast. It was in a greenstone quarry, and seemed to constitute a bed or vein about a foot thick.

Colour light red; fracture uneven; texture crystalline; streak white;

Sp. 28. *Heulandite.*

Foliated zeolite of Werner ; stilbite anamorphique of Hauy ; stilbite of Breithaupt and Rose.

This mineral, already constituted a sub-species by Werner, under the name of *foliated zeolite*, was shown by Mr. Brooke, in 1822, to differ essentially from the preceding species, with which it had been confounded by Hauy, and to constitute a peculiar species. He gave it the name of *heulandite*, from Mr. Heuland, of London, who has contributed so much to the advancement of mineralogy.*

Heulandite occurs in the same kind of rock with stilbite. Most beautiful specimens are brought from the Faroe Islands. It occurs also rather abundantly in the Kilpatrick hills, and other similar rocks in the neighbourhood of Glasgow.

Colour usually snow-white ; that of the heulandite from the Kilpatrick hills is flesh-red. It is found also brown and grey. Streak white.

Sometimes massive, or in round balls, but more commonly

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soft. Before the blowpipe melted into a brown glass. It contained numerous cavities, partially filled by a white stalactitical zeolite, evidently formed by the percollation of water through the mass. Before the blowpipe it melted into a snow-white glass.

Mr. Andrews subjected these two zeolites to analysis. The red portion was composed of

Silica,	50·37
Alumina,	10·65
Protoxide of iron,	9·19
Lime,	6·10
Water,	22·41
	98·72

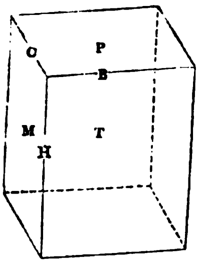
This agrees with $3AlS^3+CalS^3+\underline{f}S+10Aq$. It differs from stilbite by containing $\underline{f}S$, and 4 additional atoms of water.

The constituents of the white stalactitical zeolite were

Silica,	57·14
Alumina,	16·09
Lime,	7·77
Water,	18·60
	99·60

This is $3AlS^3+CalS^3+6Aq$, which is the formula for stilbite.

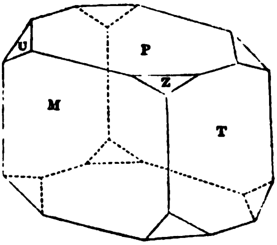
* As Mr. Brooke's name has come into general use in Great Britain, I have allowed it to remain ; but as the name *stilbite* (from *στιλϐω, to shine,*) was given to the mineral from its uncommon splendour, it would have been better to have applied it to the one of the two species which has the greatest lustre, and that is undoubtedly the *foliated zeolite*, or heulandite of Brooke.



crystallized The primary form is a right oblique prism, in which M on T is 130° 30′. The edges C, H, B, are to each other nearly as the numbers 160, 161, 162.

Most commonly the solid angles of the prism are replaced by triangular faces u, z.

P on Z 112° 15′.



Lustre of the lateral faces of the prism vitreous, but the base P has a very high degree of pearly lustre.

Sometimes nearly transparent, commonly only translucent; brittle.

Hardness 3·5; specific gravity of a very fine crystal from the Faroe Islands 2·195. Haidinger states it 2·200.

Before the blowpipe it behaves nearly as stilbite.

Its constituents are as follow :—

	*	†	Mean.	Atoms.	
Silica, . :	59·95	59·145	59·547	29·77	14·04
Alumina, . .	16·87	17·920	17·395	7·73	3·64
Lime, . .	7·19	7·652	7·421	2·12	1
Water, . .	15·10	15·400	15·25	13·55	6·39
	99·11	100·117			

Heulandite agrees with stilbite in consisting of tersilicate of alumina and tersilicate of lime. But it contains 0·64 atom more of tersilicate of alumina. Probably the constitution will be found,

4 atoms tersilicate of alumina,
1 atom tersilicate of lime,
6 atoms water.

The formula is $4AlS^3+CalS^3+6Aq$.

It differs from stilbite by containing an additional atom of tersilicate of alumina.

Sp. 29. *Brewsterite.*‡

This mineral has hitherto been observed only at Strontian in the vein containing the galena, and is always in crystals. It was considered as an apophyllite till it was examined by Mr. Brooke, and shown by him to be a peculiar species.

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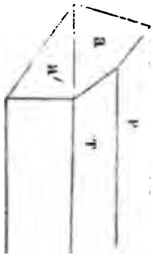
* Walmstedt, Edinburgh Jour., vii. 11.

† By my analysis. A fine snow-white crystal from the Faroe Islands.

‡ Named in honour of Sir David Brewster.



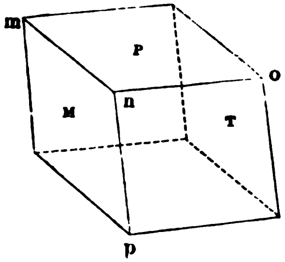
Colour white, inclining to yellow or grey.

The usual crystal is a six-sided prism terminated by two oblique and very low faces.

a on a′ 172°
P on T 90°
P on a 93° 30′

Mr. Brooke considers the primary form as a right oblique prism.

M on T 93° 40′



n m, n o, and n p, are respectively to each other as the numbers 16, 10, and 35.

The prism cleaves only parallel to the face P.

Lustre vitreous, except of the face P, which is pearly.

Hardness 4·25; specific gravity 2·432.

Before the blowpipe it loses its water, and becomes opaque; then it froths and swells up, but is difficultly fusible. It leaves a silica skeleton when fused with biphosphate of soda.

This mineral was first accurately analyzed by Mr. Arthur Connell of Edinburgh, who discovered strontian and barytes in it. This induced me to repeat the analysis. The results are as follow:—

	*	†	Atoms.	
Silica, ...	52·400	53·045	26·52	13·19
Alumina, . .	15·918	16·540	7·35	3·65
Barytes, . . .	5·827	6·050	0·63	1
Strontian, . .	7·709	9·005	1·38	
Lime, ...	1·007	0·800	0·23	0·12
Peroxide of iron, .	0·208	—	—	—
Water, . . .	12·584	14·735	13·09	6·52
	95·653	100·175		

I calculate from my own analysis, because I conceive that

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* By Mr. Connell's analysis. The specimen was an amorphous and crystallized mass mixed.

† By my analysis. The specimen consisted of fine crystals picked out with great care.

my specimen was rather purer than Mr. Connell's. If we admit a little bisilicate of lime to be accidental, brewsterite consists of tersilicates. The constitution seems to be

3 atoms tersilicate alumina,
1 atom tersilicate of barytes and strontian,
$6\frac{1}{2}$ atoms water.

The formula is $3AlS^3+(\frac{1}{3}Br+\frac{2}{3}Str)S^3+6\frac{1}{2}Aq$.

It differs from heulandite in having tersilicate of barytes and strontian in place of tersilicate of lime. It would seem also to contain half an atom more water.

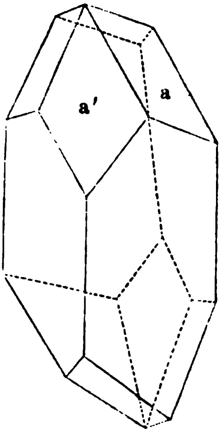
Sp. 30. *Harmotome.*[*]

Andreolite, andreasbergolite, ercinite, cross-stone, hyacinth blanche cruciform.

This mineral was early distinguished in consequence of the remarkable appearance of its crystals. Its localities are both metalliferous veins and the cavities of amygdaloidal rocks. Andreasberg in the Hartz, and Strontian in Argyleshire, have been long known as noted localities. It occurs also, though sparingly, in the Kilpatrick hills, and in many other places.

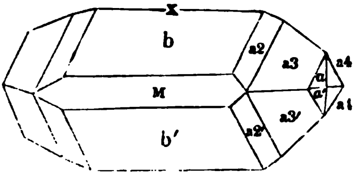
Colour white, passing occasionally into grey, yellow, red, and brown.

It is almost always crystallized, and the primary form is a right rectangular prism. One of the most common forms of the crystal is that represented on the margin, in which the base of the prism is replaced by four faces placed in the solid angles of the primary form. This is the shape of the harmotome which occurs at Strontian and in the Kilpatrick hills. The shape at Andreasberg is the same, but the crystals cross each other through the centre.



Very small transparent crystals occur pretty frequently at Strontian, having the form represented below.

b on b	69° 34′
b on adjacent plane over edge x	110° 26′
b on a^2	151° 35′
b on a^3	149° 32′
a^4 on a^4	178° 28′



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[*] From ἁρμος, *a joint*, and τεμνω, *I cut.* Because it admits of cleavage at the joints.

Fracture imperfect conchoidal, or uneven; lustre vitreous. Sometimes transparent, but most commonly only translucent; brittle.

Hardness 4·25; specific gravity of a translucent crystal from Strontian 2·400; of a transparent crystal 2·448.

Before the blowpipe on charcoal melts without intumescence into a clear bead.

The following tables exhibit the constituents of harmotome. according to the best analyses hitherto made :—

1. Barytes harmotome.

	*	†	‡	Mean.	Atoms.	
Silica, . .	56·30	47·04	48·753	50·694	25·34	13·77
Alumina, .	14·50	15·24	15·100	14·95	6·64	3·6
Barytes, . .	17·52	20·85	14·275	17·55	1·84	1
Lime, . .	1·00	0·10	3·180	1·43	0·4	0·2
Potash, . .	—	0·88	2·550	1·71	0·28	·29
Soda, . .	1·25	0·84	—	1·04	0·26	
Peroxide of iron,	—	0·24	—	0·24	0·05	—
Water, . .	11·69	14·92	14·000	13·54	12·03	6·5
	102·26	100·11	97·858			

2. Lime Harmotome.

	§.	‖	‖	Mean.	Atoms.	
Silica, . .	53·07	48·51	48·02	49·86	24·93	13·47
Alumina, . .	21·31	21·76	22·60	21·89	9·72	5·25
Barytes, . .	0·39	—	—	0·39	0·03	—
Lime, . .	6·67	6·26	6·56	6·50	1·85	1
Potash, . .	—	6·33	7·50	6·91	1·15	0·61
Protoxide of iron,	0·56	0·29	0·18	0·34	0·07	—
Water, . .	17·09	17·23	16·75	17·02	15·12	8·17
	99·09	100·38	100·61			

3. Transparent harmotome from Strontian.¶ The crystal figured in page 699.

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[*] By Gmelin and Hepel. Ann. des Mines, x. 257. The specimen was from Andreasberg, which had been originally analyzed by Klaproth, (Beitrage, ii. 83), who discovered barytes in it.

[†] By Mr. Connell. The specimen was from Strontian.

[‡] By my analysis. The specimen was from Strontian.

[§] Wernekinch, Gilbert's Annalen, lxxvi. 175. The specimen was from Annerode.

[‖] Gmelin and Hepel. Ann. des Mines, x. 255. The specimens were from Morbourg.

[¶] By my analysis.

		Atoms.	
Silica, . .	64·755	32·27	27·43
Alumina, . .	13·425	5·96	5·05
Lime, . .	4·160	1·18	1
Protoxide of iron,	2·595	0·57	0·48
Water, . .	14·470	12·86	10·89
	99·405		

The slightest inspection is sufficient to show that these three minerals, hitherto confounded together under the name of harmotome, are essentially different in their constitution, and that they in reality constitute three distinct species.

The first, to which the name *harmotome* ought to be confined, is composed of

4 atoms tersilicate of alumina,
1 atom tersilicate of barytes,
6 atoms water.

If we unite the lime, potash, and soda, with the alumina, the atoms will be just four times as numerous as those of barytes. In that case there will be a deficiency of silica. But if we consider the lime and the alkalies as accidental, then there will be a deficiency of tersilicate of alumina.

The second, which has been distinguished by the name of *lime harmotome*, is composed of

4 atoms bisilicate of alumina,
1 atom bisilicate of lime and potash,
6 atoms water.

There is a slight excess of the potash. It is to this second species that the name *phillipsite* has been given by Mr. Levy. He observed small crystals of it in specimens brought by Sir John Herschell from Aci Reale, in Sicily. They consisted of four-sided prisms terminated by four-sided pyramids, similar to the crystal of harmotome, figured in p. 349. He was not able to measure the inclinations of the faces of the pyramids *a*, *a'*, with accuracy; but he considered them as decidedly different from those of the corresponding faces in harmotome, the most obtuse being 123° 30', and the least obtuse 117° 30'. Mr. Levy observed also, that phillipsite is much softer than harmotome.*

The constitution of the third species, to which I have given the name of *morvenite*, is

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* Annals of Philosophy (2d series), x. 362.

5 atoms quatersilicate of alumina,
1 atom quatersilicate of lime,
11 atoms water.

It differs from harmotome by being transparent, while the white harmotome crystals with which it is intermixed are white and translucent. The shape of the only crystals observed at Strontian, is that figured in page 349. I drew the attention of Mr. William Phillips to it in the year 1827, who was good enough to measure several of them. The result of these measurements is stated in page 349. They agree with the crystals of harmotome, as may be seen by comparing these measurements with those given by Mr. Phillips in his Mineralogy, p. 57. Yet it will be admitted, that the appearance of the crystal is quite different from that of any other crystal of harmotome hitherto observed. If to this we add its transparency, its greater specific gravity, and the very great difference in its composition, there will, I think, be no hesitation in considering it as entitled to rank as a distinct species.

The formulas for the constituents of these three species, are as follow:

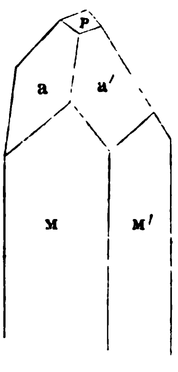
1	Phillipsite,	$4AlS^2+(\frac{2}{3}Cal+\frac{1}{3}K)S^2+6Aq.$
2	Harmotome,	$4AlS^3+BS^3+6Aq.$
3	Morvenite,	$5AlS^4+CalS^4+11Aq.$

Sp. 31. *Apophyllite.*

Albin, fisheystone, ichthyopthalmite, tesselite.

This mineral was first observed at Uton in Sweden. It has been found since in other parts of Sweden, at Arendal, in Faroe, Greenland, the Tyrol, &c., and likewise in North America.

Colour white, usually with a shade of grey, green, yellow, or red; streak white.



Usually crystallized in right square prisms. Sometimes the prism terminates in a four-sided pyramid, sometimes complete and sometimes wanting the apex, formed by the decrement on the angles of the square base of the prism.

P on M or M,	90°
M on M′, .	90°
P on a or a′, .	120°
M on a or M′ on a′,	128° 20′
a on a′ . .	104° 18′

Structure foliated, and when heated it splits into thin plates. It cleaves in the direction of all the faces of the primary prisms, but most easily in the direction of P.

Cross fracture uneven.

Lustre of P pearly; of the other faces vitreous.

Semi-transparent to translucent; brittle.

Hardness 6·25; specific gravity 2·359, by my trials. Haidinger states that of a variety from Iceland, 2·335.

Exfoliates before the blowpipe, and ultimately fuses into a white blebby glass.

In nitric acid it separates into flakes, and becomes gelatinous and semi-transparent.

The following table exhibits the constituents of this mineral, according to the best analyses hitherto made:

	*	†	†	‡	‡	§	§	‖
Silica, . .	52	51·8643	51·8564	52·50	52·900	51·76	51·18	51·008
Lime, . .	24·5	25·1992	25·2236	24·61	25·207	22·73	21·71	26·236
Potash, . .	8	5·1369	5·3067	5·08	5·266	5·31	5·27	5·888
Fluosil. of lime,	—	—	—	—	—	3·53	4·82	—
Water, . .	15	16·0438	16·9054	16·06	16·000	16·20	16·20	16·500
	99·5	98·2442	99·2920	98·25	99·373	99·53	99·18	99·632

All these analyses agree closely with each other, indicating considerable purity in the specimens examined. The mean of the whole gives us

		Atoms.
Silica, .	51·633 .	25·82 . 27·46
Lime, .	24·426 .	6·98 . 7·42
Potash, .	5·656 .	0·94 . 1
Water, .	16·114 .	14·32 . 15·23

If we allow for a small surplus of tersilicate of lime and of silica, the constitution of the mineral will be

7 atoms tersilicate of lime,
1 atom tersilicate of potash,
15 atoms water.

The formula is $7CalS^3+KS^3+15Aq$.

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* Rose; Gehlen's Jour. v. 37.

† Stromeyer; Untersuchungen, p. 286. The first specimen from Fassa in the Tyrol; the second from Diskoe on the coast of Greenland.

‡ Berzelius, Afhandlingar, vi. 181. The first specimen from Fassa, the second from Uto.

§ Berzelius, Ann. des Mines, xii. 270. The first specimen from Faroe, called tesselite by Brewster, the second from Uto.

‖ By my analysis. The specimen was from Uto.

Sp. 32. *Rhodalite.*

I give this name to a mineral from Ireland, which I got in the autumn of 1834 from Mr. Doran. It occurs seemingly in an amygdaloidal rock, and seems to have been partially acted upon by the rain and weather.

Colour between rose red and flesh red.

Texture earthy; but seems to consist of a congeries of small rectangular prisms with square bases. It is mixed with earthy carbonate of lime and with small shining crystals, having a glassy lustre and the shape of chabasite.

Hardness about 2; easily scratched by the nail. Specific gravity 2·000. But it was found impossible to free the specimen completely from air.

Before the blowpipe per se not altered. With carbonate of soda it fuses into a greenish blue transparent bead in the exterior flame, becoming yellow in the interior flame. With borax it melts into a transparent colourless bead. With biphosphate of soda does not fuse.

Freed as much as possible from carbonate of lime and from chabasite by picking, it was analyzed in my laboratory by Mr. Richardson, who found its constituents

		Atoms.
Silica,	55·9	27·95
Alumina,	8·3	3·68
Peroxide of iron,	11·4	2·28
Oxide of manganese,	trace	
Lime,	1·1	0·31
Magnesia,	0·6	0·24
Water,	22·0	19·55
	99·3	

These numbers correspond nearly with

3 atoms quatersilicate of alumina,
2 atoms quatersilicate of iron,
$\frac{1}{2}$ atom quatersilicate of ($\frac{31}{55}$ lime, $\frac{24}{55}$ magnesia),
16 atoms water.

If we were to admit the quatersilicate of lime and magnesia to be accidental, the mineral would be

$$3\text{Al}S^4+\underline{f}S^4+16\text{Aq}.$$

But the specimen analyzed was probably not quite free from impurities.

Sp. 33. *Neurolite.*[*]

The mineral to which I have given this name was sent me from Stamstead in Lower Canada, by Dr. Holmes of Montreal.

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[*] From *νευρον, a tendon*, or *string*. Named from its fibrous texture.

Colour greenish yellow.

Texture imperfectly foliated, being composed of thin fibres of some breadth; but rather obscure. The specimen had the appearance of having come from a vein about 2 inches wide. Not the least appearance of crystallization; brittle.

Fracture uneven; opaque, or only translucent on the edges.

Hardness 4·25; specific gravity 2·476.

Before the blowpipe gives out water and becomes snow-white and friable, but does not melt. With carbonate of soda fuses slowly into a transparent glass, slightly yellow, which cracks in various directions on cooling. In borax it does not seem to dissolve, but a snow-white opaque matter remains in the centre of the colourless globule. With biphosphate of soda the phenomena are the same.

The constituents of this mineral, determined by a careful analysis, were found as follow:

		Atoms.	
Silica, .	73·00 .	36·5 .	24·01
Alumina, .	17·35 .	7·71 .	5·07
Lime, .	3·25 .	0·92	1
Magnesia, .	1·50 .	0·60	
Peroxide of iron,	0·40 .	0·088	
Water, .	4·30 .	3·82 .	2·51
	99·8		

If we leave out the peroxide of iron as accidental, and unite the lime and magnesia, it is obvious that the constitution of neurolite is

5 atoms quatersilicate of alumina,
1 atom quatersilicate of lime and magnesia,
2½ atoms water.

The formula is $5AlS^4+(\frac{2}{3}Cal+\frac{1}{3}Mg)S^4+2\frac{1}{2}Aq$.

Sp. 34. *Comptonite.*

This mineral was first found lining the cavities of an amygdaloidal rock from Vesuvius, and brought into this country by Earl Compton. It was named in honour of this nobleman by Dr. Brewster, who first recognised its difference from apophyllite, with which it had been confounded.

Hitherto it has been observed only in crystals. The colour is white, and the streak white.

The primary form is a right rectangular prism, the two adjacent sides of whose base are to each other as 5·6 to 5·5.* Frequently the edges of the prism are replaced by planes converting the prism into eight-sided. The base often is replaced by two very low planes meeting at an angle of 177° 35′.

Lustre vitreous; transparent to semitransparent.

Hardness 5; specific gravity by my trials 2·427.

It has two axes of double refraction, one of which is parallel and the other perpendicular to the axis of the prism.†

Before the blowpipe it first gives off water, intumesces a little, and becomes opaque, then it melts imperfectly into a vesicular glass. The globule obtained with borax is transparent, but vesicular; that with biphosphate of soda contains a skeleton of silica, and becomes opaque on cooling. With a little carbonate of soda it melts imperfectly, but with a larger quantity it becomes infusible.‡

It dissolves and gelatinizes in muriatic acid. If it has been previously ignited so as to deprive it of its water, the mineral is still decomposed by digestion in muriatic acid, but the silica separates in powder, and does not assume the form of a jelly.

I analyzed it, but being able to employ only 7·25 grains of it in the anhydrous state, the analysis is necessarily imperfect. The result was

		Atoms.	
Silica,	36·80	18·4	13·2
Alumina,	24·52	10·9	7·8
Lime,	10·89	3·11	2·2
Peroxide of iron,	3·66	0·73	0·52
Soda,	5·58	1·39	1
Water,	13·69	12·16	8·74
	95·14		

These numbers approach nearest to

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* Brooke, Edin. Jour. vi. 112.

† Brewster, Edin. Jour. iv. 132.

‡ Haidinger, Mohs' Mineralogy, iii. 90.

8 atoms silicate of alumina,
2 atoms bisilicate of lime,
1 atom silicate of soda,
9 atoms water.

The formula representing this constitution, is

$$8AlS+2CS^2+NS+9Aq.$$

The deficiency in the analysis was owing to the accidental loss of 0·35 grain of sediment, which was washed off a watch glass before I had examined it. I suspect it to have been chiefly lime, for it was found along with the soda in the residual liquid from which all the other constituents had been separated.

Sp. 35. *Hexagonal Talc.*

This mineral was considered by Werner as the crystalline form of common Venetian talc; but its chemical constitution is inconsistent with that supposition, and as it exists in a crystalline form and is regular in its constituents, it is entitled to rank as a peculiar species. The great quantity of water which it contains, would seem to claim for it a place among the minerals described in the present section, but its other properties separate it altogether from that beautiful tribe of minerals.

Colour bluish grey.

Texture obscurely foliated.

Lustre waxy.

Opaque; feels greasy.

Hardness 1·75; specific gravity 2·772.

Occurs crystallized in very short six-sided prisms, not susceptible of accurate measurement, but apparently regular.

The specimen above described, was from Ala in Piedmont. Its constituents, by my analysis, are

		Atoms.		
Silica,	29·364	14·68	11·6	10·17
Alumina,	17·808	7·91	6·25	5·26
Magnesia,	12·144	5·06	4	4·11
Lime,	3·092	0·88	0·69	
Protoxide of iron,	26·016	5·78	4·56	4
Water,	11·200	9·95	7·86	6·9
	99·624			

The atoms of bases exceeding those of the silica, it is obvious that part of the bases are in the state of disilicates.

The constitution seems to be
5 atoms silicate of alumina,
4 atoms disilicate of lime and magnesia,
4 atoms disilicate of iron,
7 atoms water.

The formula is $5AlS+4(\frac{5}{6}Mg+\frac{1}{6}Cal)^2S+4f^2S+7Aq$.

Sp. 36. *Chlorite.*[*]

Common chlorite.

The mineral to which this name has been given from its green colour, occurs disseminated and in veins in primary rocks. Thus it is found in quartz veins in the islands of Bute and Arran, and in other localities both in England and Scotland.

Colour dark green.

Composed of small plates or scales cohering together without any visible cement.

Opaque.

Hardness 1·5; easily scratched by the nail.

Lustre silky, approaching resinous.

Sectile; easily frangible.

Specific gravity 2·823, by my trial.

Before the blowpipe fuses into a black opaque glass.

Its constituents, by the best analyses hitherto made, are as follow:

	†	‡	Atoms.
Silica,	26·8	27·624	13·812
Protox. of iron,	23·5	27·544	6·12
Alumina,	19·6	23·708	10·53
Magnesia,	14·3	10·960	4·38
Potash,	2·7	—	—
Water,	11·4	9·160	8·14
	98·3	98·996	

These analyses differ too much from each other, to deduce from both a formula indicating the constitution of chlorite. I shall therefore employ my own analysis, because I know the purity of the specimen and the locality.

The atoms of bases are to those of silica as 1½ to 1, and if we reckon the oxide of iron and magnesia together, the constitution is

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[*] From χλωρος, *green*.

[†] Berthier; Ann. des Mines, vi. 457.

[‡] By my analysis. The specimen was from Bute, and pure.

1 atom subsesquisilicate of alumina,
1 atom subsesquisilicate of iron and magnesia,
1 atom water.

The formula is $Al^{1\frac{1}{2}}S+(\frac{5}{12}Mg+\frac{7}{12}f)^{1\frac{1}{2}}S+1Aq$.

Sect. 7. *Triple Aluminous Salts.*

These salts are almost all anhydrous. But in other respects they differ much from each other. They amount to seventeen species.

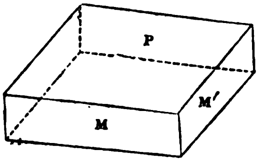
Sp. 1. *Mica.*

Muscovy glass, glacies mariæ, chlorite earth.

This mineral constituting an essential constituent of granite, gneiss, and mica slate, and appearing also pretty frequently in more recent formations, is obviously one of the most abundant of the mineral species. It is pretty evident that more than one species is at present confounded together under the name of mica, though we have not yet data sufficiently accurate to separate them with accuracy from each other.

Colour various shades of grey, passing into green, brown, or black. The lithia mica has usually a peach blossom red colour, and is distinguished by the name of *lepidolite.*

Texture always foliated, and it occurs frequently crystallized. The primary form is an oblique rhomboidal prism.



P on M 98° 40′
P on M′ 81° 20′
M on M′ 60

The acute edges of the prism are often replaced by tangent planes, which converts the crystal into a six-sided prism.

Mica occurs also crystallized in right rectangular prisms, which probably constitutes a peculiar species. But I have never had an opportunity of analyzing these rectangular crystals.

The folia may be obtained exceedingly thin and perfectly transparent. They are elastic and very tough.

Lustre pearly, often inclining to metallic upon P; that of the other faces when smooth, vitreous.

Hardness 2·5; specific gravity of fine rhomboidal prisms from Orange County, New-York, 2·824, by my trials. Haidinger states the specific gravity of a greenish black variety at

2·949. Dr. Turner found that of a dark brown, nearly opaque variety, from Cornwall, 3·08.

It appears from the experiments of Klaproth and Berzelius, that different varieties of mica behave differently before the blowpipe.

I consider the mica which crystallizes in rhomboidal prisms as the common mica. Its constituents are

	*	†	†	†	‡
Silica, . . .	47·19	46·10	46·358	47·5	49·380
Alumina, . .	33·80	31·16	36·800	37·2	23·668
Peroxide of iron, .	4·47	8·65	4·533	3·2	7·312
Oxide of manganese,	2·58	1·40	0·020	0·9	—
Lime, . . .	0·13	—	—	—	6·134
Fluoric acid, . .	0·29	1·12	0·760	0·56	—
Potash, . . .	8·35	8·34	9·220	9·60	15·292
Lithia, . . .	—	—	—	—	0·060
Water, . . .	4·07	0·87	1·040	1·39	—
	100·88	98·13	98·713	100·35	101·846

The mean of Rose's analyses is as follows:

		Atoms.	
Silica, .	46·787 .	23·39 .	45
Alumina, .	34·74 .	15·44 .	29·69
Peroxide of iron,	5·213 .	1·04 .	2
Potash, .	8·88 .	1·48 .	2·84

These atomic numbers give us

15 atoms silicate of alumina,
1½ atom tersilicate of potash,
1 atom tersilicate of iron.

The formula is $15AlS+1\frac{1}{2}KS^3+fS^3$.

My own analysis deviates too far from those of Rose, to warrant our employing it in calculating the constitution of common mica.

The constituents of the black mica of Siberia, according to the best analyses that we have, are as follow:

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* H. Rose, Poggendorf's Annalen, i. 77. The specimen was from Ochotzk in Siberia. It resembles Brodbo mica.

† H. Rose, Gilbert's Annalen, lxix. 164. The first specimen from Brodbo, the second from Kimita in Finland, the third from an iron foundery near Utön.

‡ By my analysis. The specimen was from Orange County, New-York, in fine rhomboidal prisms.

	*	†	‡
Silica,	42·5	40·00	42·01
Alumina,	11·5	12·67	16·05
Peroxide of iron,	22·0	19·03	4·93
Oxide of mangan.,	2·0	0·63	trace
Magnesia,	9·0	15·70	25·97
Potash,	10·0	5·61	7·55
Fluoric acid,	—	2·10	0·68
Moisture?	1	—	—
	98	95·74	97·10

These analyses differ so much from each other, that we are unable to deduce from them any formula for the constitution of black mica. It differs from common mica by containing magnesia. The atomic constituents of the two species analyzed by Rose, if we overlook the remarkable deficiency observable in both, may be considered as

	Atoms. 1st.	Atoms. 2d.
Silica,	20	21
Alumina,	5·63	7·13
Peroxide of iron,	3·8	0·99
Magnesia,	6·3	10·04
Potash,	0·93	1·26

The constitution of the first is nearly

6 atoms silicate of alumina,
6 atoms silicate of magnesia,
4 atoms bisilicate of iron,
1 atom silicate of potash.

The formula is $6\text{AlS}+6\text{MgS}+4\text{fS}^2+\text{KS}$.

But the constitution of the second variety is

7 atoms silicate of alumina,
10 atoms silicate of magnesia,
1 atom bisilicate of iron,
1 atom bisilicate of potash.

The formula is $7\text{AlS}+10\text{MgS}+\text{fS}^2+\text{KS}^2$.

It is clear from this, either that the specimens examined were impure, or that more than one species of black mica exists.

The peach blossom coloured micas (including the *lepidolites*,

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[*] Klaproth, Beitrage, v. 75.

[†] H. Rose, Poggendorf's Annalen, i. 80.

[‡] H. Rose, Gilbert's Annalen. lxxi. 13. It was a mica with one axis of polarization.

which are mere varieties of mica), contain lithia, which, however, I discovered in minute quantity in the common mica. The following table exhibits the constituents of these micas, according to the best analyses hitherto made:

	*	*	†	‡	§
Silica, . .	52·254	46·233	49·06	47·995	49·64
Alumina, .	28·345	14·141	33·61	23·755	24·56
Perox. of iron,	—	17·973	—	—	—
Prot. of mangan.,	3·663	4·573	1·40	7·065	3·60
Magnesia, .	—	—	0·41	0·415	—
Potash, .	6·903	4·900	4·18	14·635	16·82
Lithia, . .	4·792	4·206	3·60	3·166	1·20
Fluoric acid, .	5·069	8·530	3·45	—	—
Water, .	—	0·831	4·18	3·500	1·07
	101·026	101·387	99·89	100·475	96·86

These results differ a good deal, but they indicate the constitution of lithia mica to be a compound of simple silicates. Peroxide of iron in one case, seems to replace alumina. It seems to be

6 atoms silicate of alumina,
2 atoms silicate of lithia,
1 atom silicate of potash.

The formula is $6\mathrm{AlS}+\mathrm{LS}+\mathrm{KS}$.

There is a brown scaly powder, which occurs occasionally among primary rocks, and which hitherto has been referred to chlorite, but it is undoubtedly a variety of mica. Its specific gravity is 2·801, and its constituents

		Atoms	
Silica, . .	48·166	24·08	22·09
Alumina, . .	16·851	7·5	6·88
Peroxide of iron,	19·100	3·82	3·5
Potash, . .	6·558	1·09	1
Magnesia, .	2·916	1·16	1·06
Lime, . .	2·675	0·76	0·7
Water, . .	2·350	2·06	1·89
	98·616		

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* H. Rose, Poggendorf's Annalen, iii. 45.

† Wenz, as quoted in Mohs' Mineralogy, ii. 203.

‡ By my analysis. The specimen was from the United States.

§ The same specimen, analyzed by Mr. Fairie in my laboratory.

These atomic numbers give us the constitution of the brown mica scales (omitting the silicate of lime as accidental)

7 atoms bisilicate of alumina,
$3\frac{1}{2}$ atoms silicate of iron,
1 atom bisilicate of potash,
1 atom bisilicate of magnesia,
2 atoms water.

The formula is $7AlS^2+3\frac{1}{2}fS+KS^2+MgS^2+2Aq$.

Sp. 2. *Elaeolite.*[*]

Fettstein, lythrodes, sodaite.

This mineral occurs in Norway, near Laurvig, Stavern, and Frederiksvärm, imbedded in syenite. I have seen also specimens from the United States of America.

Colour duck blue, passing into blue and green; or brick red, passing into grey and brown.

Occurs massive, but has natural joints, parallel to all the planes, and to both diameters, of a right rhombic prism, with angles of 112° and 68°.

Fracture conchoidal.

Lustre resinous.

Translucent. Several varieties, when cut, became opalescent.

Hardness 6; specific gravity, according to Hoffmann, from 2·546 to 2·618.

Before the blowpipe melts into a white enamel.

When in powder it gelatinizes in acids.

Its constituents, according to the best analyses, are

	†	‡	Atoms.
Silica, .	44 .	44·190 .	22·09
Alumina, .	34 .	34·424 .	15·3
Soda, .	16·5 .	16·874 .	4·22
Potash, .	— .	4·733 .	0·79
Lime, .	0·12 .	0·519 .	0·14
Magnesia, .	— .	0·687 .	0·27
Peroxide of iron,	4 .	0·652 .	0·13
Water, .	— .	0·600	
	98·62	102·879	

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[*] From ελαιον, *olive oil.* Named from its fatty lustre.

[†] Vauquelin, Tableau compara, p. 228. The soda contained some potash.

[‡] C. G. Gmelin, Schweigger's Jahrbuch, vi. 82. The magnesia contained a little oxide of manganese.

If we calculate from Gmelin's analysis, and admit a slight excess of silica, and that the silicates of lime, magnesia, and iron, are accidental, the constitution of the mineral will be

3 atoms silicate of alumina,
1 atom silicate of soda and potash.

The formula is $3AlS+(\frac{1}{6}K+\frac{5}{6}N)S$.

Sp. 3. *Epidote.*[*]

Pistacite, acanticone, arendalite, delphinite, illuderite, scorza, thallite.

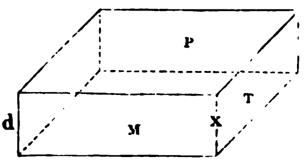
This mineral, which had been previously classed along with pyroxene, was first distinguished as a peculiar species by Hauy.

Colour green, of various shades; most commonly pistacio green. In general the green tints have a certain mixture of yellow.

Massive, but most frequently crystallized. The primary form of the crystal is a right oblique prism

M on T 115° 40′

In general the prism is elongated, and the faces are streaked. Frequently the edge x is replaced by a plane, making with M an angle of 150° 15′, and with T an angle of 145° 24′. Sometimes the edge d is replaced by one or even two planes. Thus the prism is six, eight, or ten-sided. The base P is often partly or wholly concealed by a four-sided pyramid, the faces of which rise from the lateral faces of the prism.[†]



Fracture uneven.

Translucent; said to occur transparent, but I have never seen a specimen.

Lustre vitreous, inclining to pearly upon perfect faces of cleavage.

Brittle; hardness 6.

Specific gravity, as determined by Haidinger, 3·425; by

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[*] From ἐπιδίδωμι, *I increase.* Named because the base of the primary form undergoes an increase in some of the secondary forms.

[†] For an interesting account of the crystals of epidote the reader is referred to a paper by Haidinger, Edinburgh Jour. x. 305. He deduces the forms from a different primary form. Indeed the connexion between the secondary forms and the primary forms of Hauy, which I have adopted, is far from intimate.

Descotils 3·46; by my trials 3·436 to 3·4408. I found the specific gravity of the variety called scorza 3·289.

Fuses with difficulty, and only on the thinnest edges before the blowpipe into a transparent glass. With borax it intumesces, and then yields a clear globule.

The constituents of this mineral, as determined by analysis, are as follow:—

	*	†	‡	§	§	‖	¶
Silica, . .	37	37	37	37·2	38·24	38·60	38·05
Alumina, . .	27	21	26·6	23·825	18·828	26·15	21·25
Lime, . .	14	15	20	23·075	24·080	23·84	20·20
Magnesia, . .	—	—	—	—	0·48	—	—
Protoxide of iron,	17	24	13	13·041	17·44	10·50	17·30
Protox. of manganese,	1·5	1·5	0·6	—	—	—	1·00
Moisture, . .	—	—	1·8	2·000	0·80	1·30	2·45
	96·5	98·5	99	99·141	100·588	100·35	100·25

In these analyses the proportion of silica does not differ much. But the other constituents vary a good deal in that respect. The following table exhibits the number of atoms of each constituent, deduced from the respective analyses:—

	1	2	3	4	5	6	7
Silica, . .	18·5	18·5	18·5	18·6	19·12	19·3	19·02
Alumina, .	12	9·33	11·82	10·58	8·36	11·62	9·48
Lime, . .	4	4·28	5·71	6·59	7·08	6·81	5·77
Magnesia, .	—	—	—	—	0·2	—	—
Protox. of iron,	3·77	5·33	2·9	2·9	3·87	2·33	3·84
Protox. of mangan.	0·33	0·33	0·13	—	—	—	0·22

The following table exhibits the ratios between the atoms of silica and bases in each analysis:—

Silica, .	18·5	18·5	18·5	18·6	19·12	19·3	19·02
Bases, .	20·1	19·27	20·26	20·07	19·51	20·76	19·31

In all of these the atoms of bases exceed those of silica. But in the fifth and seventh analyses this excess is very small;

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* Descotils, Jour. des Mines, v. 415.

† Vauquelin, Hauy, iii. 104.

‡ Laugier, Ann de Chim., lxix. 320.

§ By my analysis. The first specimen was in crystals, had a fine bottle green colour, and had the appearance of being very pure. The second was a superb crystallized specimen from America.

‖ By Mr. Byrkmire in my laboratory. The specimen belonged to the variety called *scorza*.

¶ The specimen was from Ireland, interspersed in a greenstone rock; had a specific gravity of 3·333. The analysis was made by Mr. Richardson, with great care, in my laboratory.

and if we exclude the magnesia (which occurring in none of the specimens except the fifth must have been accidental) almost vanishes. Now the sixth specimen analyzed was by far the finest I have ever seen. Hence it was probably purer than any of the other specimens subjected to analysis. From this I think we may conclude that epidote is composed of simple silicates.

Unless the specimen subjected to analysis contained foreign minerals mixed with the epidote, (which is very probable,) we have no other alternative but to admit that the alumina, lime, and protoxide of iron are capable of replacing each other. On that view epidote will be

$$\left.\begin{array}{c}Al\\C\\f\end{array}\right\}S$$

If we calculate the ratios of the bases in the fifth analysis, we obtain

Alumina, . .	2·16
Lime, . . .	1·83
Protoxide of iron, .	1

Hence I think it likely that pure epidote is a compound of

2 atoms silicate of alumina,
1·5 atoms silicate of lime,
1 atom silicate of iron.

The formula will be $2AlS+1\frac{1}{2}CalS+fS$.*

There is a mineral which occurs at St. Marcet, in Piedmont, in gneiss. It has been long known to mineralogists under the name of *manganesian epidote*. It has a reddish brown colour, and has the form of small flat prismatic crystals, which are generally associated in groups. Before the blowpipe it fuses easily into a black glass, and with borax into a transparent glass. These crystals were analyzed by Mr. Victor Hartwall, and found composed as follow :—

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* If we calculate the constituents of the seventh analysis, which was an olive green radiated mass found in greenstone, we obtain almost exactly (omitting the manganese)

2½ atoms silicate of alumina,
1½ atoms silicate of lime,
1 atom silicate of iron.

This differs from the fifth specimen analyzed, simply in containing an additional half atom of silicate of alumina. If this last be considered as the purest specimen, the formula will be

$5AlS+3CalS+2fS$, while the fifth gives $4AlS+3CalS+2fS$.

		Atoms.
Silica,	38·47	19·23
Alumina,	17·65	7·84
Lime,	21·65	6·1
Sesquiox. of mangan.,	14·08	2·82
Peroxide of iron,	6·60	1·32
Magnesia,	1·82	0·73
	100·27[*]	

These numbers approach pretty nearly to the fifth of the preceding analyses, with this difference, that oxide of manganese is in a great measure substituted for oxide of iron. There is rather less alumina and lime, and rather more oxides of manganese and iron than in the fifth analysis. It would appear from this mineral, that oxide of manganese in epidote may replace oxide of iron.

Sp. 4. *Axinite*.[†]

Thumerstone, thumite, yanolite.

This mineral was first described by Schreber, who found it near Balme d'Aaris, in Dauphiné, and gave it the name of *schorl violé*. It was afterwards found near Thum, in Saxony, in consequence of which Werner gave it the name of *thumerstein*. It seems to have been first called *axinite* by Karsten, from the resemblance of its crystals to the shape of an axe or hatchet.

Colour clove brown of various shades, sometimes inclining to plum blue, sometimes to pearl grey; streak white.

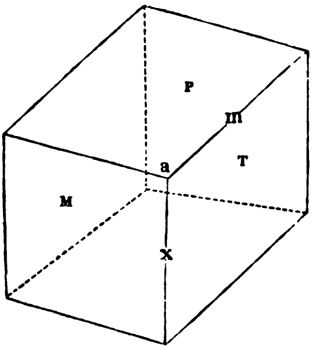
It occurs massive, but most frequently in crystals. The fundamental form of the crystal is assumed to be a doubly oblique prism, having the following angles, according to the admeasurement of Mr. W. Phillips:

P on M 134° 40′

P on T 115° 17′

M on T 135° 10′, so that the opposite edge is only 44° 50′

The solid angle a is often replaced by a plane, and the edge X is often replaced by 1, 2, or even more planes, making the



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[*] Kong. Vet. Acad. Handl., 1828, p. 171.

[†] From the resemblance of its crystals to an *axe* or *hatchet*.

prism six, eight, or ten-sided. The edge m is also sometimes replaced by a plane. Sometimes the base P is partly or wholly concealed by two oblique faces, or by an imperfect six-sided pyramid.

Fracture conchoidal, uneven; no cleavage perceptible.

Lustre vitreous, commonly splendent.

Transparent; often only translucent, sometimes only on the edges; very easily frangible.

Hardness 7; specific gravity of the Cornish specimen, as determined by Haidinger, 3·271.

Some varieties become electric when heated.

Before the blowpipe melts easily and with intumescence into a dark green glass, which becomes black in the oxidizing flame.

Its constituents are as follow:—

	*	†	‡
Silica,	44	50·5	45
Alumina,	18	16	19
Lime,	19	17	12·5
Magnesia,	—	—	0·25
Protoxide of iron,	14	9·5	12·25
Protoxide of manganese,	4	5·25	9
Potash,	—	0·25	—
Boracic acid,	—	—	2
	99	98·5	100

These analyses differ a good deal from each other. If we calculate from Wiegman's, which being the latest, has the greatest chance of being most correct, we obtain the following atomic numbers:

	Atoms.
Silica,	22·5
Alumina,	8·44
Lime,	3·57
Magnesia,	0·1
Protoxide of iron,	2·72
Protoxide of manganese,	2·00
Boracic acid,	0·66

The atoms of silica and boracic acid are 23·16, while those

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* Vauquelin, Jour. des Mines, No. xxiii. 1.

† Klaproth, Beitrage, v. 25.

‡ Wiegman; Schweigger's Jour. xxxii. 462.

of the bases are only 16·83. Hence some of the bases must be in the state of bisilicates. The alumina very nearly equals all the other bases in the number of its atoms. Hence, supposing the boracic acid to be in combination with lime and magnesia, axinite seems to be a compound of

1 atom silicate of alumina,
1 atom bisilicates of lime, iron, and manganese.

The formula is $AlS+(\frac{39}{100}Cal+\frac{35}{100}f+\frac{26}{100}mn)S^2$.

But it is not probable that all the boracic acid was obtained by Wiegman.

Axinite occurs in beds and veins in primary countries. The most remarkable localities are Dauphiné, Thum, Kongsberg, in Norway, and Botallack, in Cornwall. It used to be abundant, but of late years it has become scarce.

Sp. 5. *Tourmalin.*

Aphrizite, apyrite, cockle, indicolite, daurite, picolite, rubellite, schorl, siberite.

The word *tourmalin* is said to be a corruption of the Ceylon name for this mineral, which was originally brought to Europe from that island. There is reason to believe, as Sir William Watson has shown, that the stone was known to the ancients, and distinguished among them by the name of *lyncurium* (λυγκουριον).[*] The term *schorl*, which, for many years, was applied indiscriminately to the tourmalin and various other minerals, is said to be derived from the village of Schorlaw, in Saxony, where the mineral to which that name was originally applied was first observed.

Tourmalin occurs frequently in primary rocks, especially granite and quartz. It is found also in dolomite, talc slate, and probably in other rocks. It occurs likewise not unfrequently in veins. Its localities are so numerous that it would be vain to attempt to enumerate them.

Colours brown, green, blue, red, white, frequently black. Generally dark, and scarcely ever bright. When a crystal is viewed in the direction of the axis it is usually opaque and black, but when viewed perpendicularly to the axis it is translucent, and shows the usual colour of the variety.

It occurs commonly crystallized in prisms of three, six, eight, ten, or twelve sides, and terminated by very irregular summits. The primary form is an obtuse rhomboid, P on P 133° 20′. The angle at the summit *a* is usually replaced by a triangular plane; and the lateral angles e, e, being also replaced by planes, produce the ordinary six-sided prism of this mineral. By additional replacements of the edges, the prism becomes eight, ten, twelve-sided.

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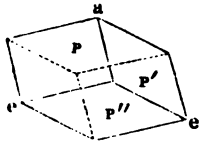
[*] Phil. Trans. 1759, p. 394.



Fracture imperfect conchoidal, uneven.

Lustre vitreous; transparent to translucent. The black tourmalins are opaque.

Hardness 8; Æpinus first determined the specific gravity of this mineral, and found it between 3 and 3·06; Haidinger states it at 3·076.

Before the blowpipe the black tourmalin of Bovey intumesces and becomes a black scoriaceous mass. The green and red kinds intumesce, but do not fuse. With borax it fuses into a transparent glass.

The transparent varieties, when heated, become electric; the termination of the prism which presents the greater number of planes becoming positive, according to Hauy, while the other end becomes negative.[*]

The analysis of the tourmalin has been attended with uncommon difficulties. Lampadius in 1818 announced boracic acid as one of its constituents.[†] This discovery was confirmed by Gruner in 1819, who likewise detected lithia in a Greenland tourmalin.[‡] The boracic acid detected amounted to 9 per cent. and the lithia to 5. The presence of lithia in tourmalin had been already discovered by Arfvedson.[§] Dr. C. G. Gmelin of Tubingen soon after analyzed several tourmalins, and found in them both boracic acid and lithia.[‖] Since that time several additional analyses have been published.

The following table exhibits the constituents of black tourmalin.

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[*] For recent experiments on the electric properties of the tourmalin, see Köhler, Poggendorf's Annalen, xvii. 146; and Becquerel, Ann. de Chim. et de Phys. xxxvii. 363.

[†] Gilbert's Annalen, lviii. 444.

[‡] Ibid. lxv. 209.

[§] Afhandlingar, vi. 166.

[‖] Schweigger's Jahrbuch, viii. 514.

	*	†	‡	
Silica,	33·048	44·10	35·20	
Alumina,	38·235	26·36	35·50	
Protoxide of iron,	23·857	11·96	17·86	
Magnesia,	—	6·96	1·13	with mangan.
Lime,	0·857	0·50	0·55	
Potash,	—	2·32	—	
Soda,	3·175	—	2·09	
Boracic acid,	1·890	5·72	—	
Moisture,	—	0·60	—	
	101·062	98·46	96·44	

The following table exhibits the most recent and exact analyses of the green and red tourmalins, that have hitherto been made:

	§	‖	¶	**
Silica,	40·30	42·127	39·37	39·16
Alumina,	40·50	36·430	44·00	40·00
Protoxide of iron,	4·85	—	—	5·96
Protoxide of manganese,	1·50	6·320	5·02	2·14
Lime,	—	1·200	—	—
Potash,	—	2·405	1·29	—
Lithia,	4·30	2·043	2·52	3·59
Boracic acid,	1·10	5·744	4·18	4·59
Moisture,	3·60	1·313	1·58	1·58
	96·15	97·582	97·96	97·02

The following table exhibits the analyses of C. G. Gmelin

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[*] Gmelin, Schweigger's Jahrbuch, viii. 514. It was a black tourmalin from Eibenstock, which had already been analyzed by Klaproth, Beitrage, v. 148. The soda contained a little potash.

[†] Leplay, Ann. de Chim. et de Phys. xlii. 270. The specimen was from Mont Rose, and had a specific gravity of 3·14.

[‡] Gmelin, Ann. des Mines (second series), iii. 219. The specimen was from Bovey, in Devonshire, and had a specific gravity of 3·246.

[§] Arfvedson, Afhandlingar, vi. 166. It was a green crystallized tourmalin, from Utön, usually called crystallized *lepidolite*.

[‖] Gmelin, Schweigger's Jahrbuch, viii. 514. It was a rubellite from Rozenu. It had been analyzed by Klaproth, Beitrage, v. 86.

[¶] Gmelin, Ann. des Mines (second series), iii. 218. The specimen was from Perm, in Siberia. Its colour was red, and its specific gravity 3·059.

[**] Gmelin, ibid. It was a green tourmalin from Brazil, of the specific gravity 3·079.

of those tourmalins that contain a notable quantity of magnesia :[*]

Silica, . .	37·65	35·48	38·79	37·81
Alumina, . .	33·46	34·75	37·19	31·61
Protoxide of iron,	9·38	17·44	5·81	7·77
Protoxide of manganese,	—	1·89	trace	1·11
Magnesia, . .	10·98	4·68	5·86	5·99
Lime, . .	0·25	trace	—	0·98
Potash, . . }	2·55	0·48	0·22	1·20
Soda, . . }		1·75	3·13	—
Boracic acid, .	3·83	4·02	3·63	4·18
Loss by ignition, .	—	—	1·86	0·24
	98·11	100·49	96·48	90·89

A bare inspection of these analyses shows that it would be useless at present to attempt to calculate the constitution of this mineral. The methods of analysis adopted are still too imperfect to render it probable that the results obtained hitherto, are sufficiently exact for our purpose. Boracic acid is obviously a constant ingredient, but the quantity is doubtless considerably greater than has hitherto been obtained. Some tourmalins contain lithia, others contain magnesia, and others potash, or soda, or both. But the great variation in the ratios of all these bodies, renders it impossible to draw any conclusion relative to them as essential constituents of tourmalin.

Sp. 6. *Bytownite*.[†]

I received the mineral to which I have given this name from Dr. Holmes, of Montreal, who informed me that it came from the neighbourhood of Bytown, in Upper Canada.

Colour light greenish-blue.

An amorphous mass, texture granular.

Fracture splintery, with some foliated portions like little crystals.

Translucent.

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[*] Gmelin, Ann. des Mines (second series), iii. 218. The first specimen was a black tourmalin from Käringbricka, in Westmanland, having a specific gravity of 3·044. The second, a black tourmalin from Rabenstein, in Bavaria, specific gravity 3·113. The third, a black tourmalin from Greenland, specific gravity 3·062. The fourth, a deep brown tourmalin from St. Gothard. The loss of 9 per cent. in the analysis of this tourmalin is remarkable. Bucholz had analyzed it before, and had met with a still greater loss.

[†] Named from Bytown, in Upper Canada, where it has been found

Lustre vitreous, shining.

Hardness 6; specific gravity 2·801.

Before the blowpipe becomes friable and white, but does not fuse. With carbonate of soda effervesces, but dissolves very slowly into an opaque white globule. With borax fuses into a transparent colourless glass, leaving a silica skeleton.

It was subjected to two separate analyses, which gave the following results:—

			Mean.	Atoms.
Silica, . .	47·735	47·400	47·567	23·78
Alumina, . .	29·695	29·60	29·647	13·17
Lime, .	8·800	9·32	9·060	2·58
Peroxide of iron, .	3·750	3·4	3·575	0·715
Magnesia, . .	trace	0·4	0·400	0·16
Soda, . . .	7·600	7·6	7·6	1·9
Moisture, . .	2·000	1·96	1·98	1·76
	99·58	99·68		

These atomic quantities approach very nearly

15 atoms silicate of alumina,
3 atoms bisilicate of lime and magnesia,
2 atoms bisilicate of soda,
1 atom bisilicate of iron.

Or, admitting the bisilicates of soda and iron to have been previously united,

5 atoms silicate of alumina,
1 atom bisilicate of lime and magnesia,
1 atom bisilicate of soda and iron.

The formula is $5AlS+(\frac{11}{12}Cal+\frac{1}{12}Mg)S^2+(\frac{2}{3}N+\frac{1}{3}f)S^2$.

Sp. 7. *Vermiculite.**

This mineral also was sent me by Dr. Holmes, to whom I am indebted for so many new and interesting species. The locality is Vermont, one of the divisions of the United States.

It is composed of micaceous looking plates cemented together by a whitish matter.

Lustre soapy; feel greasy; sectile.

Hardness 1; specific gravity 2·5252.

When heated nearly to redness it projects out with a vermicular motion as if it were a mass of small worms. Hence the name. By ignition becomes of a silvery aspect with a shade of red or yellow.

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* So named from *vermis, a worm,* because it twists itself up like a worm when heated to redness.

Infusible per se before the blowpipe. With carbonate of soda in the reducing flame gives a greenish, in the oxidizing flame an amethyst coloured glass.

I found its constituents to be

		Atoms.
Silica,	49·08	24·54
Magnesia,	16·964	6·78
Peroxide of iron,	16·12	3·22
Alumina,	7·28	3·23
Water,	10·276	9·13
Manganese,	trace	
	99·720	

These numbers approach

2 atoms bisilicate of magnesia,
1 atom bisilicate of iron,
1 atom bisilicate of alumina,
3 atoms water.

The formula is $2MgS^2+AlS^2+fS^2+3Aq$.

Sp. 8. *Lithomarge.*

The term *lithomarge*, as applied by the older mineralogists, is so indefinite that it is difficult to fix a precise idea to the name. I shall therefore restrict my description to a specimen brought me from the banks of the Tweed, near Melrose.

Colour yellowish white; streak unaltered.

Texture fine earthy; opaque; dull.

Hardness 2·5; specific gravity 2·457.

With carbonate of soda fuses before the blowpipe in the outer flame into an opaque brown bead, becoming colourless on cooling. In the inner flame the colour became fixed. With borax it did not fuse. With biphosphate of soda in the outer flame fuses into a transparent colourless bead. In the inner flame became milky.

Its constituents were

		Atoms.
Silica,	55·50	27·75
Alumina,	24·30	10·80
Peroxide of iron,	2·50	0·50
Lime,	1·55	0·42
Magnesia,	0·95	0·38
Potash,	9·25	1·54
Water,	5·80	5·15
	99·85	

The atoms of silica amount to 27·75, and those of the bases to 13·64. It consists therefore of bisilicates. The constituents seem to be

7 atoms bisilicate of alumina,
1 atom bisilicate of potash,
1 atom bisilicate of iron, lime, magnesia,
$3\frac{1}{3}$ atoms water.

Were we to admit the small quantity of bisilicates of iron, lime, and magnesia, to be accidental, the mineral would be a compound of

7 atoms bisilicate of alumina,
1 atom bisilicate of potash,
3 atoms water.

I analyzed also a specimen of what mineralogists call indurated lithomarge.

The colours were red, green, white, yellow, and brown, mixed together unequally in the same specimen.

Texture earthy; lustre dull, except in one place which was shining, and had the aspect of being polished.

Hardness about 2; specific gravity 2·2727.

Before the blowpipe per se no alteration.

With carbonate of soda it fuses into an opaque white bead. With borax into a colourless transparent glass. And with biphosphate of soda into a semitransparent bead of a dirty white colour. Its constituents were

		Atoms.
Silica, .	46·30 .	23·15
Alumina, .	25·10 .	11·15
Peroxide of iron,	9·40 .	1·88
Magnesia, .	1·15 .	0·46
Water, .	18·50 .	16·44
	100·45	

Were the magnesia combined with oxide of iron, and only accidental, we might consider the mineral as composed of

1 atom silicate of iron,
8 atoms bisilicate of alumina,
12 atoms water.

It agrees only with the mineral first described in containing bisilicate of alumina. In every other respect it is different.

Sp. 9. *Latrobite.*

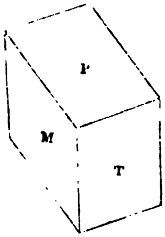
This *mineral was* first named and described by Mr.

Brooke.* It was given him by the reverend C. J. Latrobe, and came from Amitoke island, near the coast of Labrador. It is accompanied by mica and carbonate of lime, and is imbedded in a greyish coloured substance which Mr. Brooke also considers as new.

Its colour is pink, like that of some of the deep coloured varieties of lepidolite.

Its specific gravity is about 2·8

It scratches glass and is scratched by felspar.



It cleaves in three directions, parallel to the planes of a doubly oblique prism.

P on M 98° 30′
P on T 91°
M on T 93° 30′

The plane parallel to P is very dull, and the measurement obtained from it not to be confidently relied on. Those parallel to M and T afford good reflection, but one of them is brighter than the other.

Its constituents, determined by the analysis of Dr. C. G. Gmelin,† are as follow:

		Atoms.
Silica, .	44·653 .	22·33
Alumina, .	38·814 .	17·25
Lime, .	8·291 .	2·37
Oxide of mangan.,	3·160 .	0·70
Potash, .	6·575 .	1·096
	101·493	

If we leave out the manganese, the constituents are

15 atoms silicate of alumina,
2 atoms silicate of lime,
1 atom silicate of potash.

The formula is $15AlS+2CalS+KS$.

Or, admitting the silicates of lime and potash to have been previously combined, $5AlS+(\frac{2}{3}Cal+\frac{1}{3}K)S$.

Sp. 10. *Withamite.*

This mineral was discovered by Mr. Witham in Glencoe, incrusting the surface of a reddish trap rock. It was named and described by Dr. Brewster.

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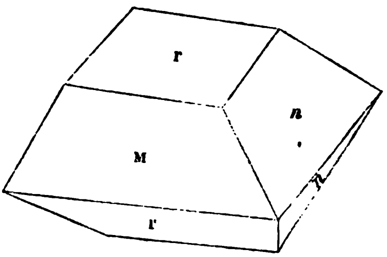
[*] *Annals* of Philosophy (2d series), v. 383.

[†] Ibid. x. 235.

Colour carmine red and pale straw yellow, in two different directions perpendicular to each other; streak white.

Minute crystals have been observed, similar to the figure in the margin.



r on T′ 128° 20′

M on T 16° 40′

By Dr. Brewster's measurement.

Hardness 6; specific gravity, as determined by Dr. Turner, 3·137; I found it only 2·857; but the specimen was not quite free from the trap rock which it incrusted.

Before the blowpipe it intumesces and fuses with difficulty into a dark greenish grey scoria. With biphosphate of soda it dissolves with effervescence into a globule, which contains a skeleton of silica, and becomes opaque on cooling. It behaves very nearly as the epidote from Arendal, with which it agrees in many of its properties.

Its constituents, as determined by Dr. Coverdale in my laboratory, are as follow. But he had only six grains of the mineral, and they were not quite free from the rock upon which the withamite was incrusted.

			Atoms.
Silica, .	55·28 .	27·64 .	12·01
Alumina, .	16·74 .	7·4 .	3·21
Peroxide of iron,	21·13 .	4·22 .	1·84
Lime, .	8·13 .	2·3 .	1
Water, .	3·25 .	2·88 .	1·2
	104·53		

These numbers approach to

3 atoms bisilicate of alumina,
2 atoms bisilicate of iron,
1 atom bisilicate of lime,
1 atom water.

The formula is $3AlS^2+2fS^2+CalS^2+1Aq$.

Sp. 10. *Isopyre.*[*]

This mineral has been hitherto found only in Cornwall. It was obtained from a mineral dealer at St. Just, and from Mr. Joseph Carne of Penzance, by the late Mr. Allan of Edinburgh. It was first described by Mr. Haidinger.

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[*] Poggendorf's Annalen, xii. 332. Named from ισος, *equal;* and πυρ, *fire;* because the effect produced on it by the blowpipe is the same as that produced on several other minerals.

Colour greyish black or velvet black, with red spots like heliotrope.

Has not been observed in crystals, but is found imbedded in granite in small amorphous pieces.

Fracture conchoidal.

Lustre vitreous.

Opaque or slightly translucent on the edges.

Streak light greenish grey.

Has a great resemblance to obsidian and opal.

Its constituents, as determined by the analysis of Dr. Turner, are as follow :

		Atoms.
Silica,	47·09	23·54
Alumina,	13·91	6·17
Peroxide of iron,	20·07	4·01
Lime,	15·43	4·41
Oxide of copper,	1·94	0·39
	98·44	

This (leaving out the oxide of copper as accidental) approaches

3 atoms bisilicate of alumina,
2 atoms bisilicate of iron,
2 atoms silicate of lime.

This supposes a slight deficiency of silica and a small excess of lime.

The formula is $3AlS^2+2fS^2+2CalS$.

Sp. 12. *Kirwanite.*[*]

The mineral to which I have given this name, occurs on the north-east coast of Ireland, filling up cavities in a kind of basaltic rock. The specimens were brought me by Mr. Doran.

Colour dark olive green.

Texture fibrous, fibres diverging from a centre and forming brushes.

Opaque.

Hardness 2; specific gravity 2·941.

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[*] Named in honour of Mr. Kirwan.

Before the blowpipe per se becomes black and partially fuses. With soda, borax, or biphosphate of soda, it fuses and forms a dark brown glass.

Its constituents, by the analysis of Dr. R. D. Thomson, are

		Atoms.
Silica, .	40·5 .	20·25
Protoxide of iron,	23·91 .	5·31
Lime, .	19·78 .	5·65
Alumina, .	11·41 .	5·08
Water, .	4·35 .	3·86
	99·95	

These numbers approach

1 atom silicate of iron,
1 atom silicate of lime,
1 atom bisilicate of alumina,
1 atom water.

The formula is $fS+CalS+AlS^2+1Aq$.

Sp. 13. *Scorilite.*[*]

I received the mineral, which, from its scoria-like appearance, I distinguish by this name, from Mexico, about ten years ago. It was labelled "Arcilla quenrada des Juan del Rio Casa del Calvaxio."

External colour reddish brown, internally dark brown; streak white.

Feels harsh, and has the aspect of a scoria. Full of small cavities like a cinder.

Opaque.

Hardness 2; specific gravity 1·708.

Before the blowpipe becomes whiter, but does not fuse. With carbonate of soda fuses readily into a yellow or bottle green transparent glass, according to the kind of flame to which it is exposed. With borax fuses into a blebby transparent yellow glass. Its constituents, by my analysis, are,

		Atoms.	
Silica, . .	58·02 .	29·01 .	11·8
Alumina, . .	16·78 .	7·45 .	3·02
Protoxide of iron,	13·328 .	2·96 .	1·2
Lime, . .	8·62 .	2·46 .	1
Water, . .	2·00 .	1·77	
	98·748		

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[*] *Named from its great resemblance to scoria.*

This corresponds very nearly with

3 atoms bisilicate of alumina,
1 atom bisilicate of lime,
1 atom tersilicate of iron.

Admitting a slight excess of this last salt, the formula is

$$3\text{AlS}^2+\text{CalS}^2+\text{fS}^3.$$

Sp. 14. *Sordawalite.**

This mineral occurs at Sordawala, in Finland, and resembles pit coal in appearance. It constitutes a layer about an inch thick on common trap.

Colour pitch black, with sometimes, though rarely, a dark grey or greenish shade.

Massive; nor can any traces of cleavage be detected.

Fracture conchoidal.

About the hardness of crown glass.

Opaque; brittle.

Lustre vitreous and semimetallic.

Specific gravity 2·580.

Becomes reddish by long exposure to the atmosphere.

Before the blowpipe melts with difficulty into a black globule. With a small quantity of soda it fuses into a blackish green glass, with a larger quantity a slag is produced. With borax it fuses into a green glass. With biphosphate of soda it leaves a silica skeleton.

Its constituents, as determined by the analysis of Nordenskiöld, are as follow:—

		Atoms.	
Silica,	49·40	24·7	12·26
Alumina,	13·80	6·13	3·04
Protoxide of iron,	18·17	4·03	2
Magnesia,	10·67	4·25	2·19
Phosphoric acid,	2·68	0·59	0·29
Water,	4·38	3·88	1·92
	99·10		

There is some difficulty in discovering the base with which the phosphoric acid is united. If we pass by this as not determinable, the constitution of the mineral will be

3 atoms bisilicate of alumina,
2 atoms bisilicate of iron,
2 atoms silicate of magnesia,
2 atoms water.

The formula is $3\text{AlS}^2+2\text{fS}^2+2\text{MgS}+2\text{Aq}$.

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* Nordenskiöld's Bidrag, p. 86.

Sp. 15. *Cauzeranite.*[*]

This mineral was first noticed by Charpentier in the transition limestone of the Pyrenees. It was afterwards described and analyzed by M. Dufresnoy.

Colour black; sometimes deep indigo blue; rarely light grey.

Always in isolated crystals. The shape is an oblique rhomboidal prism, the faces of which are inclined to each other at angles of about 84° and 96°. The inclination of the base 92° or 93°. The crystals are rarely terminated. The obtuse edge of the prism is frequently replaced. Faces striated longitudinally.

Lustre vitreous and resinous; shining. Opaque.

Scratches glass; but not quartz.

Specific gravity 2·69

Before the blowpipe fuses into a white enamel, pretty much like felspar. With biphosphate of soda it fuses into a milky bead.

Its constituents, as determined by the analysis of M. Dufresnoy, are as follow:—

		Atoms.	
Silica,	52·37	26·18	28·45
Alumina,	24·02	10·67	11·6
Lime,	11·85	3·38	3·67
Magnesia,	1·40	0·56	0·6
Potash,	5·52	0·92	1
Soda,	3·96	0·99	1·07
	99·12		

These numbers correspond with

$11\frac{1}{2}$ atoms bisilicate of alumina,
$3\frac{2}{3}$ atoms silicate of lime,
1 atom silicate of potash,
1 atom silicate of soda.

Perhaps the true formula may be

$$6AlS^2 + 2CalS + (\tfrac{1}{2}k + \tfrac{1}{2}N)S.$$

Sect. 8. *Quadruple Aluminous Salts.*

These complicated minerals are probably either mixtures or combinations of two or more simpler minerals. If we were in possession of exact analyses, and knew the simple minerals of which they are composed, we might point out the proportion of each. But this cannot at present be done. It is essential for the farther progress of this important branch of mineralogy, to describe the properties and determine the constituents of these compound minerals with as much accuracy as possible. They constitute twelve species.

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[*] Ann. de Chim. et de Phys., xxxviii. 280. Named from Cauzeran, by which the part of the Pyrenees where it occurs was distinguished.

Sp. 1. *Gieseckite.*

This mineral was brought by Sir Charles Gieseckè from Akulliarasiarsuk, in Greenland, where it occurs along with felspar. It was named by Mr. Sowerby in honour of the discoverer.

Colour externally brownish; internally, it is olive green.

Crystallized in regular six-sided prisms. Texture merely granular, so that the crystals are probably pseudomorphous.

Fracture uneven, splintery.

Lustre resinous, almost dull.

Opaque or feebly translucent on the edges.

Hardness 3·5; specific gravity, as determined by Haidinger, 2·832.

Its constituents, as determined by Stromeyer,* are

		Atoms.
Silica, . . .	46·0798 .	23·04
Alumina, . . .	33·8280 .	15·03
Magnesia, . .	1·2031 .	0·5
Protoxide of iron, .	3·3587 .	0·74
Protoxide of manganese,	1·1556 .	0·25
Potash, . . .	6·2007 .	1·33
Volatile matter, .	4·8860 .	4·34
	96·7119	

These numbers correspond best with the following constitution:

10 atoms silicate of alumina,
$1\frac{1}{3}$ atoms quatersilicate of potash,
1 atom bisilicate of iron, manganese, and magnesia,
3 atoms water.

The formula is $10AlS+1\frac{1}{3}KS^4+(\frac{1}{6}mn+\frac{2}{6}Mg+\frac{3}{6}f)S^2+3Aq$.

Sp. 2. *Nutallite.*

This mineral was found at Bolton, in Massachusetts. The first specimens brought to this country were by Mr. Nutall.

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* Gilbert's Annalen, lxiii. 272.

This induced Mr. Brooke to give it the name of that distinguished naturalist.

It occurs in crystals in a rock consisting partly of limestone and partly of a green-coloured mineral, having the aspect of amphibole. Small brown-coloured crystals (probably of sphene) are interspersed in my specimens.

The crystals are eight-sided prisms, which cleave in the direction of a right square prism, which consequently is the primary form.

Colour white, in some parts of the crystal yellowish, in others bluish or greenish. The yellowish white parts are transparent, the bluish nearly opaque, showing evidently the presence of some foreign matter; streak white.

Lustre vitreous.

Hardness 7; specific gravity from 2·748 to 2·758.

Its constituents, determined by the analysis of Dr. Thomas Muir, in my laboratory, are as follow:

		Atoms.
Silica,	37·808	18·4
Alumina,	25·104	11·11
Lime,	18·336	5·23
Peroxide of iron,	7·892	1·38
Potash,	7·305	1·21
Water,	1·500	
	97·945	

These numbers coincide nearly with

3 atoms silicate of alumina,

2 atoms silicates of lime, iron, and potash.

The formula is $3\mathrm{AlS}+2(\frac{4}{6}\mathrm{Cal}+\frac{1}{6}\mathrm{f}+\frac{1}{6}\mathrm{K})\mathrm{S}$.

Sp. 3. *Phyllite.*[*]

I give this name to a mineral which I received from Mr. Nutall. The locality is Sterling, Massachusetts. It is found in mica slate, and by the American mineralogists was considered as a variety of amphibole.

Colour brownish-black.

Composed of thin plates, without any perceptible regularity of shape.

Lustre semimetallic, splendent.

Opaque; sectile.

Hardness 5·75; specific gravity 2·889.

[*] From φυλλον, *a leaf.*

Its constituents, by my analysis, are

		Atoms.	
Silica,	38·40	19·2	16·99
Alumina,	23·68	10·52	9·3
Peroxide of iron,	17·52	3·50	3·09
Magnesia,	8·96	3·6	3·18
Potash,	6·80	1·13	1
Water,	4·80	4·26	3·77
	100·16		

These numbers approach very nearly to

9 atoms silicate of alumina,
3 atoms silicate of iron,
3 atoms silicate of magnesia,
1 atom silicate of potash,
3¾ atoms water.

The formula is $9AlS+3fS+3MgS+KS+3\frac{3}{4}Aq$.

Sp. 4. *Huronite.*

I received the mineral to which I have given the name of huronite from Dr. Holmes, of Montreal. Its locality was from the neighbourhood of lake Huron. It exists in boulder stones, nearly spherical, in a black matter like hornblende. In this black matter the huronite is imbedded, in nearly spherical masses, attached to the surrounding black matter very firmly, without any visible cement.

Colour light yellowish green; of the powder greyish white.

Structure partly in imperfect folia, partly granular.

Lustre waxy, inclining to pearly on the foliated surfaces.

Translucent on the edges.

Hardness 3·25; specific gravity 2·8625.

When ignited becomes greyish-white, and loses 4·169 of its weight.

Infusible per se by the blowpipe. When mixed with the usual fluxes it melts into a greenish glass. Not acted on by acids.

Its constituents, by my analysis, are

		Atoms.	
Silica,	45·80	22·9	33·68
Alumina,	33·92	15·07	22·1
Protoxide of iron,	4·32	0·96	1·4
Lime,	8·04	2·30	3·38
Magnesia,	1·72	0·68	1
Water,	4·16	3·69	5·4
	97·96		

These numbers approach very nearly

22 atoms silicate of alumina,
$3\frac{1}{2}$ atoms bisilicate of lime,
$1\frac{1}{2}$ atoms bisilicate of iron,
1 atom bisilicate of magnesia,
$5\frac{1}{2}$ atoms water.

The formula is $22\text{AlS}+3\frac{1}{2}\text{CalS}^2+1\frac{1}{2}\text{fS}^2+\text{MgS}^2+5\frac{1}{2}\text{Aq}$.

Sp. 5. *Erlanite.**

This mineral was first observed by Breithaupt, in 1818, at the Erla iron forges in the Saxon Erzegebirge. It forms a part of the oldest gneiss formation, and is always mixed with more or less mica. Between Gros-Pohle and Erla there exists a bed of it, at least 100 fathoms in thickness. Breithaupt has given to this mixture of erlanite and mica the name of *erlan-rock*. It has been used for 200 years as a flux by the iron smelters, and had been always considered as limestone till the mistake was rectified by Breithaupt.

Colour light greenish-grey; streak white. Sometimes compact, sometimes in small and fine granular distinct concretions.

Fracture sometimes foliated, sometimes splintery and uneven. Structure decidedly crystalline, though no regular cleavages have been observed; lustre fatty, from shining to dull.

Transparency not specified, but it is probably opaque, or only translucent on the edges, as it had been mistaken for limestone.

Hardness from 6·25 to 7; specific gravity from 3·0 to 3·1.

Before the blowpipe it melts easily into a slightly coloured transparent compact bead. With borax it fuses into a clear greenish glass. With biphosphate of soda it is decomposed, leaving a silica skeleton. Carbonate of soda easily fuses with a small, but not with a considerable proportion, of erlanite.

Its constituents, determined by the analysis of Dr. C. G. Gmelin, are

		Atoms.	
Silica,	53·160	26·58	12·24
Alumina,	14·034	6·23	2·87
Lime,	14·397	4·11	1·89
Soda,	2·611	0·65	0·3
Magnesia,	5·420	2·17	1
Peroxide of iron,	7·138	1·43	0·65
Oxide of manganese,	0·639	0·13	
Volatile matter,	0·606		
	98·005		

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* Schweigger's Jahrbuch, vii. 76.

These numbers approach

3 atoms bisilicate of alumina,
2 atoms bisilicate of lime,
1 atom bisilicate of magnesia,
1 atom silicates of soda and iron.

The formula is $3AlS^2+2CalS^2+MgS^2+(\frac{1}{3}N+\frac{2}{3}f)S$.

Sp. 6. *Pinite.*

Micarell.

This mineral was first observed in the mine called Pini, at Schneeberg, in Saxony. It has been since met with in granite in many other places, Salzburg, Auvergne, Cornwall, North America, &c. It is always in crystals, but does not appear in general to possess any regular structure; indeed there can be little doubt that different substances have been confounded together under the same name.

Colour blackish-green, or greenish grey, but it is usually covered externally with a coating of ochre, which gives it a yellowish tinge.

Crystals regular six-sided prisms, whole lateral and terminal edges are frequently replaced by tangent planes.

Lustre resinous, glimmering.

Faintly translucent on the edges, or opaque.

Fracture uneven; sectile.

Hardness 2·25; specific gravity of the variety from St. Pardoux, as determined by C. G. Gmelin, 2·7575.* Haidinger found that of the crystallized variety from France, 2·782.†

The pinite of St. Pardoux fuses before the blowpipe into a glass full of blisters, when thin splinters are presented to the flame, though it does not melt into a globule. With borax it fuses with extreme difficulty into a transparent glass, faintly tinged by iron. Biphosphate of soda has no visible action on pinite in mass, but it gradually decomposes it in powder, leaving a residue of silica. The glass becomes opaline on cooling. With carbonate of soda it dissolves slowly into an opaque glass, slightly tinged by iron, and of difficult fusion.

The pinite of St. Pardoux, by Gmelin's analysis, is composed of

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* Edinburgh Jour. xi. 88.

† Mohs' Mineralogy, iii. 139.

		Atoms.	
Silica,	55·964	27·98	21·35
Alumina,	25·480	11·32	8·64
Potash,	7·894	1·31	1
Soda,	0·386	0·09	0·06
Peroxide of iron,	5·512	1·10	0·84
Magnesia, with manganese,	3·760	1·50	1·14
Water, with animal matter,	1·410	1·25	1
	100·406		

These numbers approach very nearly to

8½ atoms bisilicate of alumina,
1 atom bisilicate of potash,
2 atoms silicates of iron and magnesia,
1 atom water.

The formula is $8\frac{1}{2}AlS^2+KS^2+2(\frac{9}{20}f+\frac{11}{20}Mg)S+Aq$.

Sp. 7. *Glauconite.**

Green earth—chlorite baldagée—talc chlorite zographique.

This mineral is a very common constituent of amygdaloid, the cavities of which are frequently filled with small concretions of this substance. It constitutes also the characteristic constituent of the green sand, to which that formation is indebted for its name. It is employed as a colour by painters, and is the mountain green used in water painting. It probably varies in its nature, yet there is a considerable resemblance between the analyses of this substance by Klaproth and Berthier.

Colour celandine green, of different degrees of intensity.

It occurs in globular and almond shaped pieces, which are sometimes hollow.

Structure earthy; fracture small grained, uneven.

Dull; streak feebly glistening.

Very soft and sectile.

Feels greasy; adheres slightly to the tongue.

Specific gravity from 2·598 to 2·632.

Not acted upon by muriatic acid, but attacked easily by aqua regia at a boiling temperature.

The following table shows its constituents, as determined by Klaproth and Berthier:—

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* From *γλαυκος, sea-green.*

	*	†	‡	§	‖
Silica, . .	51·5	53	51	46·1	57·8
Protoxide of iron, .	20·5	28	17	19·6	7·5
Alumina, . .	—	—	12	5·5	6·5
Magnesia, . .	1·5	2	3·5	3·8	19·5
Lime, . . .	—	—	2·5	—	—
Potash, . .	18	10	—	5·3	4·0
Soda, . . .	—	—	4	—	—
Water, . .	8	6	9	8·9	4·7
Grains of quartz, .	—	—	—	11·5	—
	99·5	99	99·5	100·7	100

Though the constituents in these specimens be not identical, yet the ratio between the atoms of acid and bases in each is nearly the same. In the first specimen analyzed by Berthier the atoms are

	Atoms.	
Silica, . .	23·0 .	26
Protoxide of iron, .	4·35 .	4·94
Alumina, . .	2·44 .	2·77
Magnesia, . .	1·12 .	1·27
Potash, . .	0·88 .	1
Water, . .	7·9	9

Very nearly $3fS^{2\frac{1}{2}}+2(\frac{7}{11}Al+\frac{4}{11}K)S^{2\frac{1}{2}}+MgS^{2\frac{1}{2}}+5Aq$.

Sp. 8. *Glaucolite.*[¶]

This name has been given by M. Bergmann to a mineral found by Menge near lake Baikal, in Siberia, imbedded in compact felspar, and granular limestone.

Colour lavender blue, occasionally passing into green.

Massive, presenting traces of cleavage parallel to the faces of a rhombic prism of 143° 30′, according to Brooke.

Fracture splintery; translucent on the edges; lustre vitreous.

Hardness 5; specific gravity 2·72 to 2·9.

Constituents:—

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[*] Klaproth, Beitrage, iv. 242. The specimen was from Cyprus.

[†] Klaproth, ibid., p. 241. The specimen was from the Veronese.

[‡] Klaproth, ibid., p. 244. The specimen was from East Prussia.

[§] Berthier, Memoirs, i. 157. The specimen was from Germany.

[‖] Berthier, ibid., p. 158. The specimen was from the Vosges.

[¶] Edin. New Jour. iii. 385.

		Atoms.
Silica, .	54·58 .	27·29
Alumina,	29·77 .	13·23
Lime, .	11·08 .	3·16
Potash, .	4·57 .	0·76
	100·00	

This is nearly

1 atom sesquisilicate of potash,
4 atoms sesquisilicate of lime,
16 atoms sesquisilicate of alumina.

Sp. 9. *Mountain Leather.*

This term has probably been applied to different mineral species. I confine it here to a mineral which occurs at Strontian, and which I subjected to analysis.

Colour light buff.

Composed of fine threads felted like a hat.

Feels soft, quite flexible, but tough, and like leather in appearance. Imbibes water like a spunge, and then puts on very much the appearance of wet leather.

Opaque; specific gravity 1·334.

Before the blowpipe curls up, and then fuses easily into an opaque bead. Melts with carbonate of soda into a transparent yellow bead. With borax fuses into a colourless transparent glass.

Its constituents are

		Atoms.	
Silica, .	51·650 .	25·82 .	31·11
Alumina, .	9·505 .	4·22 .	5·08
Lime, .	10·005 .	2·85 .	3·43
Magnesia, .	2·065 .	0·83 .	1
Protox. of iron, with a little mangan.,	5·805 .	1·28 .	1·54
Water, .	21·700 .	19·28 .	23·2
	100·730		

These numbers approach

10 atoms tersilicate of alumina,
7 atoms tersilicate of lime,
3 atoms tersilicate of iron,
2 atoms bisilicate of magnesia,
40 atoms water.

The formula is $10AlS^3+7CalS^3+3fS^3+2MgS^2+40Aq$.

Whether the whole water is chemically combined or not is a question. But as the mineral feels quite dry, and may be exposed to the air without losing weight, the probability is that the greatest portion at least is in combination with the mineral.

Sp. 10. *Pearlstone.*

This mineral occurs in great beds in clay porphyry, and in secondary trap rocks. It is found in Hungary, and at Cap de Gate, in Spain, where it is associated with obsidian. It is said also to have been observed in Iceland, and at Sandy Brae, in Ireland.

Common colour grey; but it is said also to occur of a black and red colour.

It consists of roundish balls from one to two inches diameter, which are composed of very thin concentral lamellæ. Sometimes it is vesicular.

Lustre strongly pearly and shining.

Translucent on the edges.

Very easily frangible.

Hardness 6; specific gravity 2·342. The specimen tried was from Spain.

Intumesces before the blowpipe, and is converted into a white frothy-like glass.

Its constituents, by my analysis, are

			Atoms.
Silica,	70·4	35·2	40·93
Alumina,	11·6	5·15	6
Peroxide of iron,	4·384	0·88	1·02
Lime,	3·000	0·85	0·98
Potash,	5·200	0·86	1
Water,	4·280	3·80	4·42
	98·864		

These numbers approach very nearly

6 atoms quintosilicate of alumina,
1 atom quatersilicate of iron,
1 atom quatersilicate of lime,
1 atom quatersilicate of potash,
4 atoms water.

The formula is $6\mathrm{AlS}^5+\mathrm{Sf}^4+\mathrm{CalS}^4+\mathrm{KS}^4+4\mathrm{Aq}$.

Sp. 11. *Saussurite.*

Iade, felspath tenace.

This name was given by Saussure Junior to a mineral which Saussure Senior had described under the name of *iade.*

It occurs usually along with diallage, constituting a beautiful rock, to which the name of *diallage rock* has been given. In this way it is found in the peninsula of the Lizard, in Cornwall. It exists in the same way in Corsica, constituting the well-known rock called Verde di Corsica. Its other localities are very numerous.

Colour various shades of grey; that from the Lizard is commonly reddish grey. Sometimes it is bluish, and sometimes greenish grey.

Texture granular.

Fracture splintery; very tough.

Translucent on the edges.

Hardness 7; specific gravity 2·801. The specimen examined was from the Lizard.

Before the blowpipe the thin edges softened, but it did not melt into a globule.

The constituents of the Lizard Saussurite, by my analysis, are as follow:—

			Atoms.
Silica,	82·168	41·08	128
Alumina,	5·072	2·25	7
Protox. of iron, with some manganese,	2·880	0·64	2
Lime,	5·520	1·57	4·9
Magnesia,	4·520	1·80	5·62
Potash, a trace			
	100·16		

These numbers (admitting a slight excess of magnesia) approach very closely to

7 atoms septisilicate of alumina,
2 atoms septisilicate of iron,
5 atoms septisilicate of lime,
5 atoms sexsilicate of magnesia.

The formula is

$$7AlS^7\,5CalS^7+2fS^7+5MgS^6.$$

Sp. 12. *Pitchstone.*

This mineral has been observed only hitherto in veins. It occurs in veins traversing sandstone in the Island of Arran, and constitutes that remarkable vein called the Skuir of Egg, in the Hebrides. It is found in many other situations, both in Scotland and on the Continent.

Usual colour dark green; but it passes on the one side into black, grey, and blue; and on the other into green, brown, yellow, and red.

It has never been observed in crystals. Structure compact, without any appearance of folia.

Fracture conchoidal, sometimes nearly even.

Lustre resinous, shining.

Feebly translucent on the edges.

Easily frangible.

Hardness 6·5; specific gravity, by my trials, from 2·338 to 2·3604.

Before the blowpipe per se it may be fused into a globule.

The constituents of the Arran pitchstone, by my analysis, are as follow:—

		Atoms.	
Silica,	63·500	31·75	37·56
Alumina,	12·736	5·66	6·73
Lime,	4·460	1·27	1·5
Protoxide of iron,	3·796	0·84	1
Soda,	6·220	1·55	1·84
Volatile matter,	8·000		
	98·712		

These numbers approach

13½ atoms tersilicate of alumina,
4 atoms quatersilicate of soda,
3 atoms quatersilicate of lime,
2 atoms quatersilicate of iron.

The formula $13\frac{1}{2}AlS^3+4NS^4+3CalS^4+2fS^4$.

The nature of the volatile matter was not determined. If it were water, as is most likely, the water will amount to 8½ atoms.

I analyzed a specimen of dark green pitchstone from Saxony, the specific gravity of which was 2·3604. Its constituents were

		Atoms.
Silica,	73·100	36·55
Alumina,	13·560	6·02
Protoxide of iron,	0·864	0·19
Lime,	1·484	0·42
Soda,	6·320	1·58
Water,	4·724	4·2
	100·042	

These constituents do not agree with those in the Arran pitchstone, showing that the constitution of the mineral is not always the same. The Saxon pitchstone is composed of

3 atoms quatersilicates of alumina,
1 atom sexsilicates of iron, lime, and soda,
2 atoms water.

The formula is $3AlS^4+(\frac{1}{11}f+\frac{2}{11}C+\frac{8}{11}N)S^6+2Aq$.

Sp. 13. *Obsidian.*

This mineral was named, as Pliny informs us, from a Roman called Obsidius, who first brought it from Ethiopia. I have a specimen which Mr. Salt brought from Abyssinia, doubtless the same locality from which Obsidius got it. It abounds in Iceland, and from Sir George Mackenzie's observations, seems to constitute part of a stream of lava from a volcano. It is found in Hungary and the Grecian Islands. I have specimens from Mexico, and many other localities are well known.

Colour velvet black, but when in very thin layers it has a brownish cast.

Never crystallized; has exactly the appearance of a mass of opaque glass.

Fracture conchoidal.

Lustre vitreous, splendent.

Breaks into very sharp edged fragments.

Translucent on the edges.

Easily frangible; streak grey.

Hardness 6·5; specific gravity of a specimen from Iceland, by my trials, 2·363; of a specimen from Mexico 2·372.

Before the blowpipe per se it melts into a vesicular glass, usually very bulky. The colour is white or grey.

I analyzed two specimens, the first from Iceland, the second from Mexico. The constituents were,

			Mean.	Atoms.	
Silica, . .	84·000	82·776	83·388	41·69	34·4
Protoxide of iron,	5·012	5·916	5·464	1·21	1
Alumina, . .	4·640	2·948	3·794	1·69	1·4
Soda, . .	3·552	5·510	4·531	1·13	0·93
Lime, . .	2·392	2·444	2·418	0·68	0·56
Water, . .	—	0·300	0·150		
	99·596	99·894			

These results do not absolutely agree, yet they show an approach to a chemical constitution. They correspond with

3 atoms novisilicate of alumina,
2 atoms novisilicate of soda,
2 atoms novisilicate of iron,
1 atom novisilicate of lime.

The formula is $3AlS^9+2NS^9+2fS^9+CalS^9$.

But the specimen of obsidian from Pasco, in Columbia, analyzed by Berthier, differs exceedingly from my results. He obtained*

			Atoms.	
Silica, . .	69·46 .	34·73 .	29·18 .	29
Potash, . .	7·12 .	1·19 .	1 .	1
Soda, . .	5·08 .	1·27 .	1·06 .	1
Lime, . .	7·54 .	2·15 .	1·8 .	2
Magnesia, .	2·60 .	1·04 .	0·87 .	1
Alumina, .	2·60 .	1·15 .	1 .	1
Peroxide of iron,	2·60 .	0·52		
Volatile matter,	0·30			
	97·30			

This approaches nearest to

2 atoms quintosilicate of lime,
1 atom quintosilicate of potash,
1 atom quintosilicate of soda,
1 atom quintosilicate of magnesia,
1 atom quintosilicate of alumina.

It is obvious from this that obsidian is not a true chemical compound.

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* Ann. des Mines (third series), v. 543.

How far the *sphærulite* of Breithaupt agrees with obsidian has not been determined by analysis, but there is a considerable resemblance in the characters of the two. It occurs at Glashütte, near Schemnitz, in Hungary, imbedded in pearlstone, and at Spechtshausen, near Tharand, in Saxony, imbedded in pitchstone.

Colour various shades of brown and grey.

Imbedded in spheroidal masses. Surface of some of them smooth, of others rough.

Fracture conchoidal.

Translucent on the edges; opaque.

Brittle.

Hardness 7·25. Specific gravity 2·416 to 2·452.

Before the blowpipe it is almost infusible, on the edges becomes covered with a sort of enamel.*

We have now finished the description of those minerals which contain alumina as an essential constituent, and in which the other essential constituents are those bases which have been already described, with the exception of oxide of iron, which is a substance so generally distributed through nature that but few minerals are found which contain no trace of it. The aluminous minerals which we have described amount to no fewer than 143 species, while the species belonging to ammonia, potassium, sodium, lithium, barium, strontium, calcium, and magnesium, taken together, amount only to 86. Those belonging to glucinum, yttrium, cerium, zirconium, and thorium, are much less numerous. Thus the species of minerals belonging to the genus aluminum, considerably exceed the species belonging to the thirteen kindred bases. We shall find iron ranking next after aluminum in the number of its species, as it is also next it of all the bases in the universality of its distribution.

GENUS X.—GLUCINUM.

The remarks made upon aluminum at the beginning of the last genus, apply equally to glucinum. It has never been met with in the metallic state, but only in the state of the white oxide, or earth, known by the name of glucina. The number of species belonging to this genus being only four, no subdivision of them is necessary. They are all (except the first) double salts; the second and third consist of two bases united each to alumina, which acts in it the part of an acid.

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* See Breithaupt's *Volständige Charakteristik des Mineral-Systems*, p. 179.

Sp. 1. *Phenakite.*

This mineral has been lately discovered by Nordenskiöld, in specimens from the Uralian mountains, mixed with emerald. It oocurs imbedded in mica slate. From its external characters it was considered as rhomboidal quartz, but its behaviour before the blowpipe proved it to be something else. It was not fusible per se, did not form a transparent glass with carbonate of soda, and was difficultly fusible in borax and biphosphate of soda.

It occurs in flat colourless rhomboids, similar to the flat crystals of calcareous spar near Freiberg.

The primary form is a rhomboid, the faces of which are inclined to each other at angles of 115° 25′, and 64° 35′, the edges and angles of which are generally replaced by tangent planes.

Texture foliated in the direction of the large diagonal of the faces; cross fracture similar to that of quartz.

Somewhat harder than quartz, and not attacked by acids.

Lustre vitreous.

Specific gravity 2·969.

Unaltered per se before the blowpipe; fuses with borax into a transparent glass; with biphosphate of soda it dissolves with difficulty, leaving a silica skeleton; with carbonate of soda it gives only a white enamel.

Its constituents, determined by the analysis of Hartwall, were:

			Atoms.
Silica,	55·14	27·57	2·01
Glucina,	44·47	13·68	1
Magnesia and alumina,	trace		
	99·61		

It is therefore a bisilicate of glucina.

Nordenskiöld named it from φεναξ, *a deceiver*, because it had been mistaken for quartz.*

Sp. 2. *Euclase.*†

This mineral was first brought from Peru, by Dombey, about the end of the eighteenth century. It was found afterwards in the mining district of Villa Rica, in Brazil. It occurs there in a chlorite slate resting on sandstone, and is associated with topaz.

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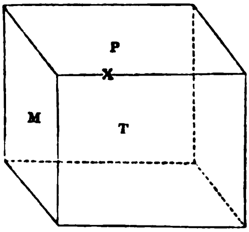
* Poggendorf's Annalen, xxxi. 57.

† *From* ευ and κλαω, *to break*, because it is easily broken.

Colour mountain-green, passing into blue and white; always pale; streak white.



Always in crystals; the primary form is a right oblique angled prism.

M on T 130° 52′

It cleaves easily parallel to the plane P, the edges X are usually replaced by three different planes. The other terminal edges of the prism, and also the lateral edges are frequently replaced also, so that its common form is that of a fourteen-sided prism, terminated by thirty-two facets, disposed in four ranges.

Fracture perfect conchoidal, and very easily obtained, for the mineral is very easily frangible. Hence the name euclase, imposed by Hauy, which signifies *easily broken.*

Lustre vitreous, splendent.

Transparent or semitransparent.

Hardness 7·5; specific gravity, as determined by Haidinger, 3·098. Mr. Wilson Lowry found it 2·907. Hauy gives the specific gravity, on the authority of the School of Mines, 3·0625.

Before the blowpipe it fuses into a white enamel, but requires a strong heat. In borax it dissolves slowly and with effervescence, into a colourless glass. In biphosphate of soda it is decomposed with strong effervescences, leaving a silica skeleton, which is whiter than common. With a small quantity of carbonate of soda it fuses into a white bead; with a greater quantity it gives a transparent glass, which becomes opaque on cooling.

Vauquelin analyzed it, and detected in it silica, alumina, glucina and oxide of iron. But he sustained a loss of 28 per cent., and his specimen was too small to permit a repetition of the analysis.* It was afterwards analyzed with much care by Berzelius, who published the result of his experiments in 1819. It is as follows:†

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* Jour. *des Mines, x., lv. 509.*

† *Kong. Vet. Acad. Handl.,* 1819, p. 136.

			Atoms.
Silica, . .	43·22 .	21·61 .	3·22
Alumina, .	30·56 .	13·58 .	2·02
Glucina,	21·78	6·70 .	1
Peroxide of iron,	2·22 .	0·44 .	0·06
Peroxide of tin,	0·70 .	0·07	
	98·48		

It is obviously a compound of

2 atoms silicate of alumina,
1 atom silicate of glucina,

with a little silicates of iron and tin.

The formula is $2AlS+GS$.

Sp. 3. *Emerald.*

Beryl, aquamarine, agustite.

The finest specimens of the emerald come from Peru. The present mine is situated in the valley of Tanca, in Santa Fe, between the mountains of New Granada and Popayan. Emeralds occur there, according to Humboldt, in veins traversing hornblende slate, clay slate, and granite. The ancients procured their emeralds from Egypt, but of late years they have been discovered in Mount Zalora, in Upper Egypt, where they occur in granite and mica slate. In Siberia, the mineral occurs in the granite district of Nertschinsk, and in the Uralian and Altai mountains. It has been found in Cornwall by Mr. A. R. Barclay, crystallized in a dark grey quartz wall of a vein traversing the granite and slate of St. Michael's Mount.* They have been found also in Scotland, at Kinloch Raimoch and Cairngorm, and it is said also in Rubislaw quarry, near Aberdeen. They occur in the beautiful crystallized granite of the Morne mountains in Ireland. Fine specimens are met with in the county of Wicklow, and in the mountains above Dundrum. There are various localities in Germany, Sweden and North America, not to mention Brazil, where it is found in the sand of rivers.

Colour emerald green, passing into blue, yellow and white. The bright green variety is called *emerald*, while all the pale varieties are denominated *beryl.* Streak white.

Sometimes it occurs massive, but most commonly crystallized. The primary form is the regular six-sided prism, the terminal edges and angles of which are usually replaced by tangent planes. The crystals are frequently very large, even a foot in length.

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* Annals of Philosophy (second series), x. 383.

Fracture conchoidal uneven.

Lustre vitreous. Hardness 7·5 to 8.

Specific gravity of an emerald variety determined by Haidinger, 2·732; of an apple green variety, 2·678. I found that of some small emeralds from Brazil 2·580.

Before the blowpipe the edges are rounded, and a shapeless vesicular scoria is produced. It fuses with borax.

The following table exhibits the constituents of this mineral, according to the best analysis hitherto made:

	*	*	†	†	‡	§
Silica, . . .	64.5	68	68·5	66·45	68·35	66·858
Alumina, . . .	16	15	15·75	16·75	17·60	18·406
Glucina, . . .	13	14	12·5	15·50	13·13	12·536
Oxide of chromium, .	3·25	—	0·3	—	—	—
Peroxide of iron, .	—	1	1	0·60	0·72	2·002
Oxide of columbium, .	—	—	—	—	0·27	—
Lime, . . .	1·6	2	0·25	—	—	—
Water, . . .	2	—	—	—	—	—
	100·35	100	98·3	99·3	100·07	99·802

These results approach each other so closely as to leave no doubt about the chemical constitution, and the purity of the specimens examined by the different experimenters. My analysis gives the following atomic numbers:

		Atoms.
Silica, .	33·43 .	8·68
Alumina, .	8·18 .	2·12
Glucina, .	3·85 .	1

The mean of all the analyses gives

		Atoms.
Silica, .	67·11 .	33·55
Alumina,	16·58 .	7·36
Glucina, .	13·44 .	4·1

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* Vauquelin, Jour. des Mines, No. xxxviii. 98, and xliii. 563. The first specimen was an emerald from Peru, the second a beryl.

† Klaproth, Beitrage, iii. 219 and 226. The first specimen an emerald, the second a beryl.

‡ Berzelius, Afhandlingar, iv. 192. The specimen was from Brodbo, in Sweden.

§ By my analysis. The specimen was a Siberian beryl. The iron was scattered through *the stone in small* rifts, and must therefore be considered *as accidental.*

There is an excess of alumina, and a deficiency of silica in my analysis. But there is an excess in the others. The constitution of emerald is obviously

2 atoms tersilicate of alumina,
1 atom tersilicate of glucina.

The formula is $2AlS^3+GS^3$.

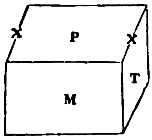
Sp. 4. *Chrysoberyl.*

Cymophane.

This mineral occurs in greatest abundance in Brazil, where it is accompanied by topazes in the alluvial soil. In Ceylon it has been observed in the sand of rivers. It is met with at Nerbschink, in Siberia, but the nature of its repository in that quarter is unknown. At Hoddam, in Connecticut, it occurs in granite.

Colour asparagus green, passing into greenish white, olive green, and yellowish grey. When viewed in a direction perpendicular to the base of the primary prism, it shows a bluish opalescence. Streak white.

It occurs in irregular grains, roundish pieces and in crystals. The primary form is a right rectangular prism. Sometimes the base P is replaced by two planes, produced by decrements on the edges X.



Sometimes the edges and the prism are replaced by one or more planes, making the prism 8 or 12-sided. In such cases the prism is terminated by a six-sided or eight-sided irregular pyramid.

Lustre vitreous.

Transparent to translucent.

Cross fracture conchoidal. Splits easily parallel to the face M.

Hardness 8·5; specific gravity, according to Haidinger, 3·754. Seybert found that of the Hoddam variety from 3·508 to 3·597. I found picked specimens of the Brazil variety to vary from 3·7112 to 3·733.

Does not melt before the blowpipe per se, nor can it be fused along with carbonate of soda. With borax and biphosphate of soda it fuses perfectly, but not without a good deal of difficulty.

Chrysoberyl was analyzed long ago by Klaproth, who *obtained*

Alumina, . .	71·5
Silica, . .	18
Lime, . .	6
Oxide of iron, .	1·5
	97[*]

Arfvedson analyzed it in 1822, and obtained

Alumina, .	81·43
Silica, . .	18·73
	100·16[†]

But he seems to have taken for silica the portion of matter left, when the mineral was heated with caustic potash and digested in muriatic acid. This was rather unaccountable both in him and Klaproth, as the difficulty of dissolving the mineral might have suggested the suspicion that it had not been completely decomposed. Seybert analyzed chrysoberyl in 1824, and made the important discovery that it contains glucina. The following table exhibits the result of his analyses:[‡]

Alumina, .	73·60 .	68·666
Glucina, .	15·80 .	16·000
Silica, . .	4·00 .	5·999
Protoxide of iron,	3·38 .	4·733
Oxide of titanium,	1·00 .	2·666
Moisture,	0·40 .	0·666
	98·18	98·730

After seeing Seybert's analyses, I made three successive analyses of the Brazilian chrysoberyl, and Dr. Thomas Muir, at that time, in my laboratory, made another. Our results almost coincided. The following table shows them:

		Atoms.
Alumina, .	76·752 .	34·11
Glucina, .	17·791 .	5·47
Protoxide of iron,	4·494 .	1
Volatile matter,	0·480 .	
	99·517	

This constitutes

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[*] Beitrage, i. 102.

[†] Kong. Vet. Acad. Handl., 1822, p. 90.

[‡] Silliman's *Jour. viii. 109.* The first specimen was from Hoddam, the *second from Brazil.*

5½ atoms sexaluminate of glucina,
1 atom aluminate of iron.

The formula is $5\frac{1}{2}GAl^6+fAl$.

I did not examine whether the volatile matter was pure water. Its quantity was so small that I conceive it could have been nothing else but hygrometrical water, mechanically lodged in the powder of the mineral.

Besides these three species, there are other three minerals which contain a notable quantity of glucina as an essential constituent. These are *gadolinite*, *pyrochlore* and *helvine*. The first two of these belong to the next genus. The last will be described under the genus *manganese*.

GENUS XI.—YTTRIUM.

Yttrium bears so close a resemblance to glucinum in many of its properties, that we need not be surprised to find it follow the same law in the manner in which it occurs in the mineral kingdom. It has never been found in any other state than that of the oxide, or earth called *yttria*. It is found in combination with phosphoric acid, with columbic acid, and with silica; so that in the mineral kingdom it always acts the part of a base.

The number of species belonging to this genus is so small that no subdivision is necessary.

Sp. 1. *Phosphate of Yttria.*

Thorina.

This mineral was discovered in the neighbourhood of Lindisnäs in Norway, by Mr. Tank, in a coarse grained granite, along with another mineral resembling *orthite*. It was at first taken for a zircon from its colour and appearance. Its nature was determined by Berzelius, to whom specimens of it had been sent.

Colour yellowish brown, very similar to that of the Frederikvörn zircons, for which on that account it was taken.

Form irregular; but it has been observed crystallized in octahedrons with a square base; the pyramids usually separated by a very short prism.[*]

Foliated with cleavages in more than one direction.

Cross fracture uneven, splintery.

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[*] Haidinger, Ann. des Mines (2d series), iii. 231.

Dull externally. Foliated fracture resinous, cross fracture fatty.

Translucent when in thin splinters.

Easily scratched by the knife. Hardness 4·25; specific gravity 4·5577.

Before the blowpipe it behaves very like phosphate of lime. Per se it is infusible, but becomes darker coloured. When heated in a tube it gives out no water. With borax it dissolves slowly into a colourless glass, which by flaming can be rendered milk-white, and which when fully saturated becomes white on cooling. With biphosphate of soda, it dissolves with great difficulty into a clear colourless glass. This constitutes the great distinction between phosphate of yttria and phosphate of lime, the latter fusing very easily with the phosphoric salt. With carbonate of soda it gives, with a strong effervescence, a light grey infusible slag. With boracic acid it dissolves with difficulty, but gives, with the addition of iron, phosphuret of iron in abundance.

In acids it is quite insoluble.

Its constituents, as determined by Berzelius,* are as follow:

		Atoms.	
Phosphoric acid,†	33·49	7·44	1
Yttria,	62·58	11·38	1·52
Diphosphate of iron,	3·93		
	100·00		

It is obviously a compound of 1 atom phosphoric acid and 1½ atom yttria, or a subsesquiphosphate of yttria. The formula is $Y^{1\frac{1}{2}}\underset{\cdot}{P}$.

Sp. 2. *Yttrotantalite.*

Of this mineral there are three subspecies, differing from each other in the proportion of yttria which they contain.

Subsp. 1. *Black Yttrotantalite.*

Dicolumbate of yttria.

This mineral occurs at Ytterby, in a rock composed of red felspar and mica, in pieces never exceeding the size of a hazel nut, but sometimes exhibiting the rudiments of a crystallized form.

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* Kong. Vet. Acad. Handl., 1824, p. 334, and Annals of Philosophy (2d series), xii. 116.

† *With a little fluoric acid.*

Colour black; powder grey.

Structure foliated.

Lustre metallic.

Opaque.

Hardness 5·5; specific gravity 5·395.

Before the blowpipe decrepitates feebly and becomes dark brown, but does not fuse per se. When a piece is heated to redness, the colour often becomes unequal, and some portions remain quite black; showing that the constituents are unequally distributed. It dissolves with difficulty in biphosphate of potash, and the bead is either colourless or yellowish. If additional portions of the mineral be added while the heat is continued, a saffron coloured glass is obtained, which becomes at last opaque. A white matter continues, which does not dissolve in the glass. In borax it dissolves with more ease. The glass is colourless or yellowish, but becomes opaque during the cooling; or, if the portion of the mineral be small, it remains transparent, but becomes white and muddy when heated anew. With carbonate of soda it fuses with effervescence; after which the alkali is absorbed by the charcoal, and leaves a white mass, which is no farther altered.

Insoluble in acids.

It is most easily distinguished from gadolinite by its behaviour with borax. Gadolinite, when heated with borax, becomes dark green, or almost black.

Its constituents, according to the analysis of Berzelius,* are as follow:

		Atoms.	
Columbic acid,	57·00	2·21	4·17
Tungstic acid,	8·25	0·53	1
Yttria,	20·25	3·68	6·94
Lime,	6·25	1·78	3·35
Peroxide of iron,	3·50	0·70	1·32
Oxide of uranium,	0·50	0·017	0·03
	95·75		

In what way these constituents are united in the mineral, it is impossible to say. The atoms of the bases are rather more than double those of the acids, so that the constituents must be in the state of disalts. The numbers approach nearest to

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* Afhandlingar, iv. 268.

5 atoms dicolumbate of yttria,
1 atom dicolumbate of iron,
4½ atoms tristungstate of lime.

But a more accurate analysis would be requisite before the chemical constitution of this mineral could be considered as settled.

Subsp. 2. *Yellow Yttrotantalite.*

Triscolumbate of yttria.

This mineral is met with at Ytterby, in thin irregular layers, between felspar. Sometimes also in grains, the largest of which, according to Berzelius, does not exceed a peppercorn in size.

Colour yellowish-brown, in some cases inclining somewhat to green. Generally striped with greenish stripes or flakes. Powder white.

Foliated with only one cleavage; cross fracture uneven.

Lustre of the plates resinous, of the fracture vitreous.

About the hardness of crown glass; opaque.

Specific gravity, as determined by Ekeberg, 5·882.

Before the blowpipe it does not fuse, but decrepitates feebly, and changes its colour to straw yellow. If a grain of the mineral be laid upon a pearl of biphosphate of soda, and a good reducing flame be applied, a portion is dissolved, leaving a silica skeleton, which is taken up by the glass with extreme difficulty. On cooling, the bead (before yellow) becomes colourless, and gradually cracks in different directions, showing a weak, but pure green colour. When the mineral, in powder, is laid on biphosphate of soda, and a good reducing heat applied, the whole fuses into a muddy glass, green while hot, but assuming, on cooling, a weak rose-red colour, and becoming opaque. This last phenomenon, proceeding from the presence of tungstate of iron, is not constant. In borax it fuses in the reducing flame, to a clear yellow glass, becoming still more yellow on cooling. When the bead is again gently heated, and then left to cool, it becomes milk-white. It is not attacked by carbonate of soda.

Insoluble in acids.

Its constituents, by Berzelius's* analysis, are:

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* Afhandlingar, iv. 272.

		Atoms.
Columbic acid, .	60·124 .	2·33
Yttria, . .	29·780 .	5·41
Lime, . .	0·500 .	0·14
Oxide of uranium,	6·622 .	0·24
Peroxide of iron, .	1·155 .	0·23
Tungstic acid with tin,	1·044 .	0·06
	99·225	

The atoms of bases amount nearly to three times as many as the atoms of acids. Hence the bases are in the state of trisalts.

The preceding numbers agree very nearly with

9 atoms triscolumbate of yttria,
1 atom triscolumbate of lime, uranium and iron.

Subsp. 3. *Brownish-black Yttrotantalite.*

This mineral occurs mixed with the yellow yttrotantalite in thin plates, or very rarely in grains, which show no marks of crystallization.

Colour black, with a very slight shade of brown; powder white.

Fracture fine granular.

Lustre between vitreous and resinous.

When in thin layers translucent; almost colourless by transmitted light, or only slightly yellowish.

As hard as the other two subspecies.

Specific gravity not determined, but heavy.

Does not fuse before the blowpipe, but decrepitates weakly, and becomes light yellow. With biphosphate of soda it exhibits the same phenomena as the yellow yttrotantalite, with this difference, that the colour is a weaker green, and that the red colour cannot be produced when pure pieces are employed, without the saturated glass bead becoming opaque, and slightly greenish-grey. With borax it gives a clear yellow glass, which with a greater addition becomes opaque and yellowish-brown. It does not fuse with carbonate of soda.

It is not attacked by acids.

Its constituents, as determined by Berzelius, are as follow:

		Atoms.
Columbic acid,	51·815	2·01
Yttria,	38·515	7·00
Lime,	3·260	0·93
Oxide of uranium,	1·111	0·04
Tungstic acid with tin,	2·592	0·16
Peroxide of iron,	0·555	0·11
	97·848	

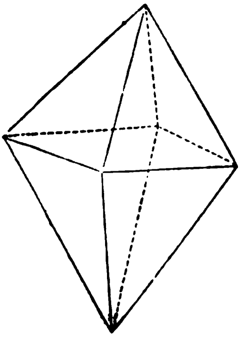
The atoms of bases are four times as numerous as those of the acids. The constitution of the mineral seems to be

7 atoms tetracolumbate of yttria,
1 atom tetracolumbate of lime, uranium, and iron,
0·16 atom tungstate of lime.

Doubtless the tungstate of lime is accidental. This remark probably applies to all the three subspecies of yttrotantalite.

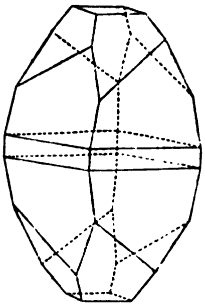
Sp. 3. *Fergusonite.*[*]

This mineral was discovered by Sir Charles Giesecké at Kikertaursak, near Cape Farewell, in East Greenland, where it is found in imbedded groups and single crystals, in white quartz. It was first distinguished as a peculiar species, and described by Mr. Haidinger.[†]



Colour dark brownish-black; but in very thin scales it appears of a pale liver-brown, or yellowish-brown colour, and is translucent. In large crystals it becomes opaque; streak pale brown.

It occurs frequently crystallized, and the primary form, according to Haidinger, is an octahedron, whose faces are isosceles triangles, the terminal edges of the pyramids being 100° 28′, and their lateral edges 128° 27′. The most common crystal is that represented in the margin. There is a short prism interposed between the two pyramids, and the pyramid terminates in another more acute four or eight-sided pyramid, truncated at the summit.



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[*] Named in honour of Mr. Ferguson, of Raith.

[†] Edin. Trans. x. 274.

Brittle; hardness 5·75; specific gravity, as determined by Dr. Turner, 5·800; by Mr. Allan 5·838.

When heated in a glass tube it gives out a little water, becomes first darker, and then light yellow. It is infusible per se before the blowpipe on charcoal. In borax it dissolves with difficulty. The glass, while hot, has a yellow colour; but a white portion remains undissolved. The saturated glass, by flaming, becomes opaque, and assumes a dirty yellowish-red colour. With biphosphate of soda it dissolves slowly, the undissolved portion remaining white. The glass in the oxidizing flame becomes yellow; in the reducing flame it is colourless, or, when fully saturated with the mineral, inclining to red. With carbonate of soda it is decomposed, and fuses, leaving a reddish slag.

Its constituents, as determined by the analysis of Mr. Victor Hartwall,* are as follow:

		Atoms.
Columbic acid,	47·75	1·85
Yttria,	41·91	7·62
Protoxide of cerium,	4·68	0·72
Zirconia,	3·02	0·80
Oxide of tin,	1·00	0·10
Oxide of uranium,	0·95	0·03
Peroxide of iron,	0·34	0·07
	99·65	

The atoms of bases are almost five times as numerous as those of the acids (including the peroxide of tin). The constitution of the mineral agrees best with the following numbers:

4½ atoms pentacolumbate of yttria,
1 atom pentacolumbate of cerium, zirconia, uranium and iron.

But the probability is, that all these constituents are not in chemical combination.

Sp. 4. *Gadolinite.*†

This mineral was first observed by Captain Arhenius in the quarry at Ytterby, about three Swedish miles from Stockholm, where a white felspar was collected for the porcelain manufactory of Stockholm. A short account of it was published by Geijer, in 1788.‡ Gadolin published a chemical analysis of it in 1794.[*] It was examined again by Ekeberg, in 1797;[†] by Berzelius, in 1815,[‡] and by Dr. Steele and myself, in 1831.

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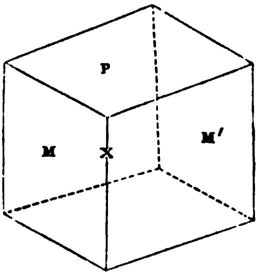
* Kong. Vet. Acad. Handl., 1828, p. 167.

† Named in honour of Professor Gadolin, who first analyzed it.

‡ *Crell's* Annalen, 1788, ii. 229.



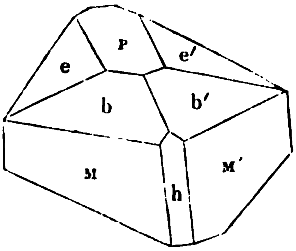
Colour greenish-black, very dark, so as to appear on a slight inspection, velvet black.

Usually massive, but it occurs also crystallized. The primary form seems to be an oblique rhombic prism, in which

M on M′ 115° by the common goniometer,

P on the edge X 98°.

The figure in the margin represents a crystal in the possession of Mr. Brooke, the measurement of which, by Mr. W. Phillips, is as follows:



P on h	98°
M on e	100°
M′ on e′	
M on b	153°
M′ on b′	
b on b′	120°
e on e′	120°
b on e	130°
b′ on e′	

Fracture flat conchoidal.

Lustre vitreous, inclining to resinous.

Slightly translucent on the edges, almost opaque.

Hardness 6·5. Specific gravity, by my trials, from 4·1493 to 4·1795. Geijer states it at 4·223; Rinman at 4·03; Gadolin states that of a specimen, not quite free from felspar, at 4·028. Haidinger found it 4·238, and Hauy 4·0497.

Before the blowpipe alone it intumesces, throwing out cauliflower-like ramifications, and becomes white, giving off water. When heated in a matrass it gives out no moisture, but when the matrass is beginning to fuse, it shines suddenly as if it had taken fire. With borax it fuses readily into a dark glass, strongly coloured by iron, which in the reducing flame becomes dark bottle-green. With biphosphate of soda it fuses with extreme difficulty. The glass assumes an iron tint, and the fragment becomes rounded on the edges, but remains white and opaque, so that the phosphoric acid does not in this instance effect the separation of the silica. With carbonate of soda the vitreous gadolinite changes into a semifluid brownish red scoria; the splintery variety fuses into a globule, if the quantity of flux be not too great. On platinum foil neither of them gives the least indication of containing manganese.

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[*] Kong. Vet. Acad. Handl., 1794, p. 137.

[†] Ibid, 1797, p. 156.

[‡] Afhandlingar, iv. 228.

Gadolinite was analyzed by Ekeberg, Klaproth, and Vauquelin, but neither of them detected the presence of oxide of cerium, though it seems to be an essential constituent of this mineral. This substance was discovered in it by Berzelius, who found the constituents of gadolinite

Silica,	24·16	25·80
Yttria,	45·93	45·00
Protoxide of cerium,	16·90	16·69
Protoxide of iron,	11·34	10·26
Moisture,	0·60	0·60
	98·93	98·35

The specimen analyzed in my laboratory by Dr. Steele and myself, I had purchased from a German mineralogist, who had found it in a Swedish cabinet. It weighed several ounces. During the pounding, small grains of metallic platinum were detected in it, very irregularly distributed. The whole obtained weighed 2·33 grains, from at least 200 grains of gadolinite. Dr. Steele found in this gadolinite a notable quantity of glucina, which was overlooked by Berzelius, though the presence of it had been noticed by Ekeberg. The constituents obtained by Dr. Steele and myself, are the following. I have added a second analysis made during the winter 1834–5, by Mr. Richardson.

			Atoms.
Silica,	24·330	24·65	12·16
Yttria,	45·330	45·20	8·06
Protoxide of cerium,	4·333	4·60	0·88
Glucina,	11·600	11·05	3·91
Protoxide of iron,	13·590	14·55	3
Manganese,	trace	—	
Moisture,	0·986	0·50	
	100·179	100·55	

The excess of weight was probably owing to the yttria not having been completely deprived of carbonic acid. If we were to admit the protoxide of iron to be accidental, gadolinite would consist of

2 atoms silicate of yttria,
1 atom silicate of glucina and cerium.

But the probability is, that other principles besides the platinum grains are mechanically mixed in it.

There is a variety of gadolinite at Korarvet, in the neighbourhood of Fahlun, which differs from the mineral just described in several particulars.

Its fracture is even or fine granular, while that of common gadolinite is conchoidal and glassy. It has a dark brownish yellow colour, while common gadolinite is black. When heated to redness it becomes white, inclining to greyish blue, without changing its form; whereas common gadolinite either froths or swells up, and when heated to redness, gives the phenomena of apparent combustion. With borax it gives very slowly an iron green glass, whereas common gadolinite gives a glass so dark that it is opaque. Its powder is dark brown, while that of common gadolinite is almost white, having merely a greyish green shade.

Its constituents, as determined by Berzelius, are

Silica,	29·18
Yttria,	47·30
Protoxide of iron,	8·00
Lime,	3·15
Glucina,	2·00
Protoxide of cerium,	3·40
Protoxide of manganese,	1·30
Water,	5·20
	99·53

Berzelius considers it as composed of

Common gadolinite,	83·67
Bisilicate of lime,	7·27
Silicate of glucina,	2·90
Silicate of cerium,	4·33
Silicate of manganese,	1·83
	100·00*

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* Afhandlingar, iv. 388.

Sp. 5. *Orthite.*[*]

This mineral occurs at Finbo, constituting very thin veins in gneiss, and is very scarce. Berzelius gave it the name of *orthite*, because, though scarcely exceeding $\frac{1}{16}$th of an inch in thickness, it may be traced running more than two feet in length.

Colour black; powder grey, inclining to brown.

Massive; fracture small conchoidal.

Lustre vitreous.

Opaque, even when in very thin plates.

Hardness 7; specific gravity 3·288.

Brittle; easily frangible.

Before the blowpipe per se it froths like a zeolite, and becomes yellowish brown. In a stronger heat, it melts with effervescence into a black vesicular glass. With biphosphate of soda it fuses with difficulty, leaving a silica skeleton. The globule in the reducing flame becomes colourless, but in the oxidizing flame fine yellow, which disappears on cooling. With saltpetre it gives sometimes greater, sometimes smaller indications of manganese. With borax it dissolves easily into a clear glass, which in the reducing flame becomes greenish, but in the oxidizing flame blood-red, which last colour, in a great measure, vanishes on cooling. It is decomposed by soda, but not fused.

It dissolves when digested in acids, and gelatinizes.

Its constituents, as determined by Berzelius,[†] are as follow:

			Atoms.	
Silica, . . .	36·25	32·184	16·09	30·94
Lime, . . .	4·89	7·96	2·27	4·36
Alumina, . . .	14·00	14·81	6·57	12·63
Protoxide of cerium, .	17·39	20·51	3·15	6·05
Protoxide of iron, .	11·42	12·38	2·75	5·3
Yttria, . . .	3·80	2·87	0·52	1
Protoxide of manganese,	1·36	3·36	0·74	1·42
Water, . . .	8·70	5·36	4·76	9·1
	97·81	99·434		

From the great number of ingredients, and their different proportions in the two specimens, there seems little doubt that more than one chemical compound exists mechanically mixed in orthite. The third column exhibits the atomic ratios deduced from the second analysis. The atoms of silica and of bases agree in number; hence it is clear that all the bases are in the state of simple silicates. The following constitution approaches pretty near to the numbers in the table:

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[*] From ὀρθος, *straight.*

[†] Afhandlingar, v. 32. The first specimen was from Finbo, the second from Gottlieb's vein.

$12\frac{1}{2}$ atoms silicate of alumina,
6 atoms silicate of cerium,
$5\frac{1}{3}$ atoms silicate of iron,
$4\frac{1}{3}$ atoms silicate of lime,
$1\frac{1}{2}$ atom silicate of manganese,
1 atom silicate of yttria,
9 atoms water.

The formula is

$$12\frac{1}{2}\mathrm{AlS}+6\mathrm{CrS}+5\frac{1}{2}\mathrm{fS}+4\frac{1}{3}\mathrm{CalS}+1\frac{1}{2}\mathrm{mnS}+\mathrm{YS}+9\mathrm{Aq}.$$

Sp. 6. *Pyrorthite.*[*]

This mineral occurs along with gadolinite, in a granite vein at Korafsberg, a quarter of a Swedish mile west from Fahlun.

Colour pitch black; some effloresced pieces are yellowish brown.

Occurs in long needles, usually agglutinated together. They consist of four-sided prisms, longitudinally streaked, and having commonly a large streak in the centre, giving the prism the appearance of being divided into two.

Longitudinal fracture small conchoidal or splintery; cross fracture uneven.

Lustre resinous; opaque.

Hardness 2·75; specific gravity 2·19.

Before the blowpipe it catches fire, glows, and consumes without flame. When the combustion is at an end the mineral is white, with a shade of grey or red, and so light that it is difficult to prevent it from being dissipated before the blowpipe. It fuses per se with difficulty into a black enamel. With borax or biphosphate of soda it fuses into a clear glass. The addition of saltpetre shows the presence of manganese. In carbonate of soda it does not dissolve.

When digested in acids it dissolves, leaving behind a black powder.

Its constituents, as determined by Berzelius, are

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[*] From *πυρ*, *fire*, and *ὀρθος*, *straight*.

			Atoms.
Silica,	10·43	5·22	5·8
Alumina,	3·59	1·59	1·8
Lime,	1·81	0·51	0·57
Protoxide of cerium,	13·92	2·14	2·4
Protoxide of iron,	6·08	1·35	1·5
Yttria,	4·87	0·90	1
Protoxide of manganese,	1·39	0·30	0·33
Water and volatile matter,	26·30		
Charcoal,*	30·00		
	98·39†		

It is evident that the atomic numbers belonging to the constituents of this mineral (leaving out the water and charcoal), are different from those of orthite. The following constitution approaches the numbers in the table:

2½ atoms silicate of cerium,
2 atoms disilicate of alumina,
1½ atom disilicate of iron,
1 atom disilicate of yttria,
½ atom disilicate of lime,
⅓ atom disilicate of manganese,

The formula is

$$2\tfrac{1}{2}CrS+2Al^2S+1\tfrac{1}{2}f^2S+Y^2S+\tfrac{1}{2}Cal^2S+\tfrac{1}{3}mn^2S.$$

But this formula is too complex to represent a simple chemical compound.

GENUS XII.—CERIUM.

The resemblance between the oxides of cerium and yttria in their chemical properties, is so close that it is exceedingly difficult to separate them from each other, and nature seems to have taken a pleasure in combining them together. Like yttrium, cerium never occurs in the mineral kingdom except in the state of oxide. The number of species known is so small that no subdivision is necessary.

Sp. 1. *Carbonate of Cerium.*

I have never seen this mineral, nor even a description of it. elius says that it has been found at Bastnäs, in cerite.‡

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* Allowing 1·61 for loss.

† Afhandlingar, v. 49.

‡ Kong. Vet. Acad. Handl., 1824, p. 134.

The artificial carbonate of cerium is a silvery-white tasteless powder, insoluble in water, even when acidulated with carbonic acid.

Sp. 2. *Cerite.*

Silicate of cerium—ochroite.

This mineral has been hitherto found only at Bastnäs, near Redderhyttan, Westmanland, where it occurs in a bed of gneiss.

Colour intermediate between clove brown and cherry red, passing into grey; streak white.

Always massive; granular; fracture uneven and splintery; brittle.

Lustre adamantine.

Translucent on the edges.

Hardness 5·5; specific gravity, as determined by Haidinger, 4·912.

Infusible per se by the blowpipe; fuses with borax into a yellow bead, which becomes paler on cooling.

Its constituents, as determined by Hisinger,* are

		Atoms.
Silica,	18	9
Peroxide of cerium,	68·59	10·55
Peroxide of iron,	2·00	0·40
Lime,	1·25	0·35
Water and carbonic acid,	9·60	8·53
	99·44	

These numbers approach

1 atom silica,
1 atom peroxide of cerium,
1 atom water.

It is therefore a hydrous silicated peroxide of cerium. The formula is $CrS+Aq$.

Sp. 3. *Thulite.*

This mineral has been found at Souland, in Tellemark, in Norway, in a rock consisting chiefly of quartz.

Colour rose-red; streak greyish-white.

Texture usually granular; but Mr. Brooke informs us that he found it to yield to mechanical division an oblique prism, with angles of 87° 30′ and 92° 30′, but he could perceive no distinct cleavage transverse to the axis of this prism.

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* Afhandlingar, iii. 283.

Lustre vitreous; translucent on the edges.

Hardness about 6, or between 5 and 6; but the grains separate so easily from each other that it is rather difficult to determine the hardness; specific gravity 3·1055.

Before the blowpipe it fuses with carbonate of soda into an opaque greenish-white bead. With borax it fuses into a colourless transparent bead, which, by the addition of saltpetre, assumes a sensibly violet colour, indicating the presence of a trace of manganese.

Its constituents, by my analysis, are as follow:—

		Atoms.
Silica, .	46·10	23·05
Peroxide of cerium,	25·95	3·7
Lime, .	12·50	3·57
Peroxide of iron,	5·45	1·1
Potash, .	8·00	1·33
Moisture, .	1·55	1·38
	99·55	

There is an excess of silica, because the thulite was mixed with numerous small globules of quartz, which it was impossible to exclude entirely. The constituents, allowing for this excess, indicate

3 atoms bisilicate of cerium,
3 atoms bisilicate of lime,
1½ atoms bisilicate of potash,
1 atom bisilicate of iron.

The formula is $3CrS^2+3ClS^2+1\frac{1}{2}KS^2+\underline{f}S^2$.

Sp. 4. *Fluate of Cerium.*

This mineral was found by Berzelius in Albite, both at Brodbo and Finbo, in the neighbourhood of Fahlun.

Colour dark tile red, or almost yellow. The colour deepens when the mineral is wetted; powder white or slightly yellowish.

Found crystallized in regular six-sided prisms, the axis of which is commonly shorter than the diameter of the base. The angles of the prism are frequently replaced by planes.

Fracture uneven or splintery.

Little lustre; brittle.

Hardness 4; specific gravity 4·7.

Infusible per se before the blowpipe. In borax and biphosphate of soda it fuses slowly but completely. The bead in the exterior flame is blood red, but loses its colour on cooling. In the interior flame the glass is colourless at all temperatures. In carbonate of soda it does not fuse, but swells out and is decomposed.

The constituents, according to Berzelius'* analysis, are

		Atoms.
Peroxide of cerium,	82·64	11·8
Yttria,	1·12	0·2
Fluoric acid,	16·24	13
	100·00	

But he ascertained that both protoxide and peroxide of cerium exist in the mineral, and concluded from his observations, that they are in the proportion of 1 atom of protoxide to 2 atoms peroxide. We perceive that the mineral is composed of simple fluates. Therefore (neglecting the yttria) it must consist of

1 atom fluated protoxide } of cerium.
2 atoms fluated peroxide }

Sp. 5. *Subsesquifluate of Cerium.*

This mineral was found by Berzelius at Finbo, and like the preceding it occurs very sparingly.

Colour a beautiful yellow with some red, and (when the mineral is impure) brownish yellow; powder fine yellow.

Usually massive; sometimes it exhibits the rudiments of the garnet or rhomboidal dodecahedron.

Lustre vitreous.

Opaque, or only translucent on the edges.

Hardness 5; specific gravity not determined.

Soluble in hot sulphuric acid, solution yellow; dissolves in muriatic acid with the evolution of much chlorine; a little white powder remains undissolved.

Not fusible before the blowpipe per se. But the colour becomes much darker. On cooling, the original colour is restored, though it continues redder than at first. With borax, biphosphate of soda, and carbonate of soda, it behaves like the last species.

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* *Afhandlingar*, v. 56.

Its constituents, according to the analysis of Berzelius,[*] are,

		Atoms.
Peroxide of cerium,	84·20	12·03
Fluoric acid,	10·85	8·67
Water,	4·95	4·4
	100	

These numbers approach to 1½ atom peroxide of cerium for every atom of fluoric acid. The constitution of the mineral is obviously

1½ atom peroxide of cerium,
1 atom fluoric acid,
½ atom water.

It is therefore a hydrous subsesquifluated peroxide of cerium.

Sp. 6. *Yttrocerite.*

This mineral occurs very sparingly at Finbo and Brodbo, near Fahlun, imbedded in quartz.

Colour violet blue, inclining to grey and white, sometimes white. These colours generally alternate in layers in the same specimen.

Massive; but has a foliated structure, and cleaves in the direction of a right rhombic prism, measuring by the common goniometer about 97°.[†]

Fracture uneven.

Lustre glistening.

Opaque.

Hardness 5; specific gravity 3·447.

Before the blowpipe it loses its colour and becomes white, before it has been exposed to a red heat, but does not fuse. With the addition of gypsum it melts easily into a bead, which does not become clear to what degree soever of heat it be exposed.

When heated in a glass tube it does not phosphoresce, but gives out a little moisture and loses its colour.

When in fine powder it dissolves completely in muriatic acid with the assistance of heat. The solution has a yellow colour.

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[*] Afhandlingar, v. 64.

[†] Brooke's Familiar Introduction, p. 458.

Its constituents, according to the analysis of Berzelius,* are

			Mean.
Lime, .	47·63 to	50·00 .	48·81
Yttria, .	9·11	8·10 .	8·60
Peroxide of cerium,	18·22	16·45 .	17·33
Fluoric acid, .	25·04	25·45 .	25·24
	100	100	

The quantity of fluoric acid was determined by the loss sustained in the analysis. But as the mineral contains water, it is obvious that the quantity of acid must be a little overrated.

The atomic weights are

		Atoms.
Lime, .	13·9 .	8·9
Yttria, .	1·56 .	1
Peroxide of cerium,	2·47 .	1·58
Fluoric acid,	20·19 .	12·9

There is an excess of fluoric acid. But this excess is probably owing to its quantity being overrated. The mineral then may be considered as composed of simple fluates. The constitution is obviously

9 atoms fluate of lime,
1½ atom fluated peroxide of cerium,
1 atom fluate of yttria.

The yttria and oxide of cerium were imperfectly separated from each other. It is possible, therefore, that its real constitution may be

7 atoms fluate of lime,
1 atom fluated peroxide of cerium,
1 atom fluate of yttria.

Sp. 7. *Allanite.*

This mineral was discovered by Sir Charles Giesecké at Allick, near the southern extremity of East Greenland, where it is imbedded in quartz, and associated with mica and albite. It was first noticed by Mr. Allan of Edinburgh about the year 1803. I analyzed it soon after, ascertained its peculiar nature, and gave it the name *Allanite.*† Since that time I have seen a specimen in the Museum of the East India

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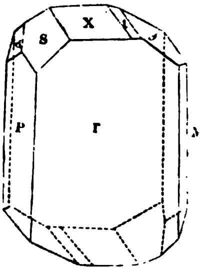
* Afhandlingar, iv. 151.

† *In honour of* Mr. Allan, who first noticed it.

Company, brought from Hindostan, but I could not learn the exact locality.

Colour black, verging upon green or brown; powder and streak greenish grey.



It is usually massive, but occurs also crystallized. The most complete crystal I have seen is that figured in the margin. From this figure it would appear that the primary form is a right oblique four-sided prism, M on T about 115°.

The following are the measurements of the angles taken by Mr. Haidinger, with a common goniometer:

r on M	129°	y on r	109°
r on P	116	s on x	156½
M on P	115	x on t	164½
s on r	135½	x on y	151
d on r	124½	t on y	166½

Faint traces of cleavage are observable parallel to P and r, but they are very indistinct and interrupted.

Fracture imperfect conchoidal.

External lustre dull, internal shining and resinous, inclining to metallic.

Opaque. The edges of very thin splinters are somewhat translucent, and of a dark yellowish-brown colour.

Brittle; easily frangible.

Hardness 6; specific gravity, when pure, 4·001. But it is almost always mixed with mica, and then its specific gravity varies from 3·119 to 3·797.

Before the blowpipe froths and melts imperfectly into a brown scoria.

Gelatinizes in nitric acid.

By ignition loses water, amounting to 3·98 per cent. of its weight.

Its constituents, by my analysis, were:

		Atoms.
Silica,	35·4	17·7
Lime,	9·2	2·6
Alumina,	4·1	1·8
Protoxide of iron,	22·86	5·0
Protoxide of cerium,	31·48	4·8
Volatile matter,	3·98	3·5
	107·02	

But a later and more accurate analysis has been given by Stromeyer,[*] who found its constituents as follows:

		Atoms.
Silica,	33·021	16·51
Alumina,	15·226	6·76
Protoxide of cerium,	21·600	3·32
Protoxide of iron,	15·101	3·35
Protoxide of manganese,	0·404	0·09
Lime,	11·080	3·16
Water,	3·000	
	99·432	

It is obvious that the mineral consists of simple silicates, in the following proportions:

2 atoms silicate of alumina,
1 atom silicate of cerium,
1 atom silicate of iron,
1 atom silicate of lime,

Sp. 8. *Pyrochlore.*[†]

This mineral was first discovered by Mr. Tank at Frederickvärn, in Norway, along with polymignite and phosphate of yttria. It was afterwards observed by Wöhler and Berzelius, and Alexander Brogniart, near Laurvig, in Norway, in the zirconsyenite formation, where, besides zircons, it was associated with green elaeolite, large black hornblende crystals, and green apatite. It was described and analyzed by Wöhler, in 1826.[‡]

Its colour is reddish-brown, not unlike brown titanite, and the fresh fracture is almost black.

In thin splinters it is translucent and appears brown; in larger pieces it is quite opaque.

It is almost always crystallized, but the crystals are so firmly attached to the rock that they can scarcely be extricated entire. The primary form, according to Dr. G. Rose, is the regular octahedron. The largest crystal which Wöhler observed did not exceed the size of a pea. They are usually immersed in felspar, and not unfrequently in elaeolite, and seem at first sight like irregular points, varying from the size of a needle point to that of a pea.

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[*] Poggendorf's Annalen, xxxii. 292.

[†] From πυρ, *fire*, and χλωρος, *greenish-yellow*.

[‡] Poggendorf's Annalen. vii. 417.

It scratches fluor spar, and is itself scratched by felspar, so that its hardness is about 5. Specific gravity, as determined by G. Rose, from 4·206 to 4·216.

Fracture conchoidal without any indication of cleavage; streak and powder light brown.

Lustre between vitreous and resinous.

When heated before the blowpipe per se it becomes brownish-yellow, assumes a shining lustre, and fuses with great difficulty into a blackish-brown slaggy mass. With borax, in the oxidizing flame, it fuses into a reddish-yellow transparent bead, which by flaming becomes opaque and yellow. When a considerable portion of the assay is added, the glass, on cooling, assumes the form of a white enamel. In the reducing flame we obtain a dark red globule as from ferruginous titanic acid, which by flaming is converted into a light greyish-blue enamel, often striped with streaks of pure blue. In biphosphate of soda it dissolves completely, with some effervescence at first. The glass in the oxidizing flame is yellow while hot, but on cooling it becomes grass-green. In the reducing flame the colour is changed into a dark red, with a shade of violet, as is the case with titanic acid when it contains some iron. In the oxidizing flame this colour disappears, and the bead, if not too long exposed, becomes of a fine grass-green colour. With carbonate of soda, on the platinum foil, it shows the green reaction from manganese.

Its constituents, according to the analysis of Wöhler, are:

Titanic acid, . .	62·75
Lime, . . .	12·85
Protoxide of uranium,	5·18
Peroxide of cerium,	6·80
Protoxide of manganese,	2·75
Peroxide of iron, .	2·16
Peroxide of tin, .	0·61
Water, . .	4·20
	97·30

with a trace of fluoric acid and magnesia.

This mineral was found also in Siberia by Humboldt, and Wöhler has announced that he has found in that variety 5 per cent of *thorina.** Till his new analysis (which he has promised) appear, it would be needless to attempt to calculate the constitution of this complex mineral.

GENUS XIII.—ZIRCONIUM.

Zirconium agrees with the preceding genera in never occurring in the earth except in the state of the oxide called zirconia. For many years the genus was limited to a single species, but four other species having been successively discovered, it now consists of five species.

Sp. 1. *Zircon.*

Hyacinth, jargen, silicate of zirconia.

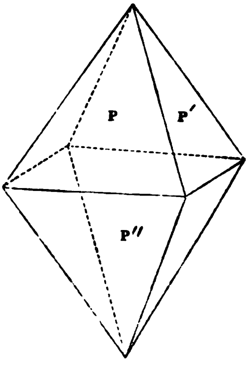
This mineral is found sometimes in the sands of rivers. In this way it is found at Expailly, in Auvergne, and in Ceylon. In the United States, in Carinthia, &c., it occurs in gneiss. At Frederickvärn, in Norway, it is a constituent in zirconsyenite.

Colour red, brown, yellow, grey, green, white. None of them are bright except some of the red tints; streak white.

It occurs usually crystallized. The primary form is an octahedron with a square base.

P on P′ 123° 20′
P on P″ 84° 20′

The angles at the base are often replaced by planes, which, when they become large, convert the crystal into a four-sided prism, terminated by a quadrangular pyramid with rhombic planes, similar to the most common form of harmotome. Sometimes the edges of the base are also replaced by planes, which makes the prism eight-sided.



Several cleavages may be detected, but they are all rather obscure. Fracture conchoidal.

Lustre more or less adamantine.

Transparent to translucent; sometimes only on the edges; refracts doubly very powerfully.

Brittle; rather easily frangible.

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* Poggendorf's Annalen, xxvii. 80.

Hardness 6·5. When pounded in an agate mortar, it did not occasion any diminution of its weight.

I found the specific gravity of pure crystals from Expailly, 4·681; Mr. Wilson Lowry found it 4·721; Haidinger states it at 4·505.

Before the blowpipe (if pure) it loses its colour, but retains its transparency, and does not fuse. Infusible with carbonate of soda, and with biphosphate of soda. Melts with borax into a transparent glass.

The constituents of zircon are as follow:

	*	†	Mean.	Atoms.
Silica,	33·48	33·32	33·4	16·7
Zirconia,	67·16	66·00	66·58	17·75
	100·64	99·32	99·98	

These two analyses erring in opposite ways, the mean of the two must be almost perfectly accurate. It is obviously a simple silicate of zirconia, composed of

1 atom silica,
1 atom zirconia.

The formula is ZrS.

Sp. 2. *Sillimanite*[‡].

This mineral was found at Petty Pog, in the township of Saybrook, Connecticut, and was described and analyzed by Mr. Bower.[§] For the specimen which I had an opportunity of examining, I was indebted to the kindness of Mr. Nutall.

Colour dark grey, passing into clove brown.

It is crystallized in long four-sided prisms, which are often bent, and whose faces are too rough to admit of accurate measurement. Mr. William Phillips obtained by cleavage a small prism, with angles of about 88° and 92°, but he was unable to determine the position of the base.[||] Mr. Bower says, that the base is inclined on the axis at an angle of 113°.

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[*] Berzelius, Kong. Vet. Acad. Handl., 1824, p. 306. Those crystals were selected for analysis, which became colourless on ignition.

[†] Dr. Thomas Muir, in my laboratory. The crystals were from Expailly, and carefully selected. There was also a trace of iron found in the analysis.

[‡] In honour of Professor Silliman.

[§] Jour. of the Academy of Sciences of Philadelphia, iii. 375, as quoted by Haidinger.

[||] Phil. Mag. (2d series), i. 401.

The crystals have a fibrous structure.

Lustre vitreous; brittle; easily frangible.

Translucent on the edges.

Hardness 6; specific gravity, by my trials, (on only 5·64 grains) 3·1636; but the quantity was rather too small for much accuracy. Mr. Bower states it at 3·410.

Infusible before the blowpipe per se, nor does it melt into a bead with borax.

It was analyzed by Dr. Thomas Muir, in my laboratory, who found the constituents

Silica,	38·670	19·33	12·05
Alumina,	35·106	15·60	9·75
Zirconia,	18·510	4·93	3·08
Peroxide of iron,	7·216	1·60	1
	99·502*		

If we admit the peroxide of iron to be only a mechanical mixture, the constitution of sillimanite will be

3 atoms silicate of alumina,
1 atom silicate of zirconia.

Perhaps the excess of alumina may be a combination with the protoxide of iron in the mineral.

Sp. 3. *Æschynite.*

Colour black; streak dark grey, almost black.

Lustre semimetallic.

Occurs crystallized in rhomboidal pyramids.

Hardness between 6 and 8; specific gravity 5·550.

Berzelius informs us that Menge brought it from Minsk in the Ural, and that he himself had determined its behaviour before the blowpipe.†

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* Mr. Bower the original namer and describer of this mineral, gives its constituents as follows:

		Atoms.
Alumina,	54·11	24·04
Silica,	42·67	21·33
Peroxide of iron,	2·00	
Water,	0·51	
	99·29	

This approaches a silicate of alumina. Is it not possible that Mr. Bower may have analyzed *bucholzite* instead of *sillimanite?*

† I have not succeeded in finding any such account in the English translation of Berzelius on the blowpipe. It occurs, he says, in page 216, I presume, of the German edition.

It was analyzed by Hartwall, and found composed of

			Atoms.
Titanic acid,	56	10·66	9·8
Zirconia,	20	5·33	4·93
Peroxide of cerium,	15	2·14	2
Lime,	3·8	1·08	1
Peroxide of iron,	2·6	0·52	0·48
Peroxide of tin,	0·5	0·05	
	97·9[*]		

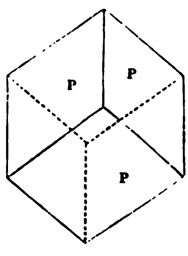
Obviously

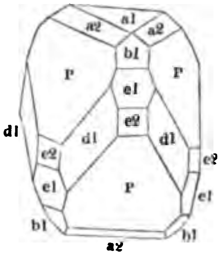
5 atoms titaniate of zirconia,
2 atoms titaniate of peroxide of cerium,
1 atom titaniate of lime,
½ atom titaniate of peroxide of iron.

Sp. 4. *Eudyalite.*

This mineral was discovered by Sir Charles Giesecké in Greenland, at Kangerluarzuc, in the same bed from which the sodalite was procured.

Colour sometimes rose red, sometimes hyacinth red.





Sometimes massive, sometimes crystallized. The crystals have somewhat the aspect of rhomboidal dodecahedrons with their edges truncated. Mr. Levy has given a description of a very fine crystal in possession of Mr. Brooke, the figure of which is given in the margin. He considers the primary form as an acute rhomboid, in which

P on P 73° 40′

The following are the incidences calculated by Mr. Levy,[†] all of which, he says, agree within ten minutes with observation.

P on P	73° 40′	P on a1	112° 33′
b1 on b1	96 15	b1 on a1	129 34
e1 on e1	63 59	e1 on a1	101 40
a2 on a2	126 44	a2 on a1	148 49
e2 on e2	120	e2 on a1	90
d1 on d1	120	d1 on a1	90

Structure foliated; fracture imperfect conchoidal or splintery.

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[*] Poggendorf's Annalen, xvii. 483.

[†] Edinburgh Journal, xii. 81.

Lustre vitreous.

Hardness 6; specific gravity, by my trials, 2·9036. Stromeyer states it at 2·90355.

Before the blowpipe it fuses into a leek green scoria.

When pulverized it gelatinizes in acids.

Its constituents, as determined by the analysis of Stromeyer,[*] are

		Atoms.	
Silica,	53·325	26·66	27
Zirconia,	11·102	2·96	3
Lime,	9·785	2·79	2·83
Soda,	13·822	3·45	3·49
Protoxide of iron,	6·754	1·50	1·52
Protoxide of manganese,	2·062	0·45	0·45
Muriatic acid,	1·034	0·22	0·22
Water,	1·801	1·6	
	99·685		

I repeated this analysis, and verified it so far that I got all the constituents, but not in the same proportions, because my specimen was not quite pure.[†] The above numbers approach

3½ atoms bisilicate of soda,
3 atoms bisilicate of lime,
3 atoms tersilicate of zirconia,
1½ atom tersilicate of iron,
½ atom silicate of manganese.

Sp. 5. *Polymignite.*[‡]

This mineral occurs sparingly in the zirconsyenite of Frederikvärn, in Norway. Specimens of it were sent by

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[*] Untersuchungen, p. 438.

[†] The result of my analysis was

Silica,	51·654
Zirconia,	3·248
Lime,	12·624
Soda,	17·776
Protoxide of iron,	6·092
Protoxide of manganese,	6·816
Muriatic acid,	0·952
Water,	1·750
	100·912

The specimen was in small fragments, mixed with much impurity.

[‡] From *πολυς, many*, and *μιγνυμι, I mix*.

Mr. Tank to Berzelius, to whom we are indebted for its description and analysis.[*]

Colour black; powder brown.

Always crystallized in long slender prisms having a rectangular base, whose edges are more or less truncated. The prism has frequently two opposite faces broader than the two others. Its length varies from 1 to 4 lines. Mr. G. Rose has shown that its primary form is a rhomboidal octahedron, the three axes of which are to each other $:: \sqrt{2{\cdot}114} : \sqrt{4{\cdot}255} : 1$, and the dihedral angles are 136° 28, 116° 22, and 80° 16.[†]

Lustre splendent and nearly metallic.

Fracture conchoidal without any perceptible cleavage; opaque.

Scratches glass and is not itself scratched by the knife, 7? specific gravity 4·806.

Before the blowpipe it remains unaltered, and gives out no water. With borax it fuses easily, and forms a glass coloured by iron. It becomes opaque by flaming when an additional dose of borax is added. It then assumes an orange colour, and if still more borax be added it remains opaque after cooling. When fused with tin it gives a red colour, approaching yellow. Biphosphate of soda dissolves it also, but with more difficulty. In a reducing heat the glass becomes reddish, and this colour is not altered by tin. In the oxidizing flame the colour becomes lighter, and more approaching to yellow. In carbonate of soda it is decomposed without fusion, and becomes greyish red. An additional dose causes it to fuse completely. When a little borax is added, it gives some marks of reduction, but inconsiderable ones.

Its constituents, determined by Berzelius, from the analysis of 10·16 grains of it, are as follow:

			Atoms.
Titanic acid,	46·3	8·43	7·02
Zirconia,	14·4	3·84	3·2
Peroxide of iron,	12·2	2·44	2·03
Lime,	4·2	1·20	1
Sesquioxide of manganese,	2·7	0·54	0·47
Peroxide of cerium,	5·0	0·71	0·6
Yttria,	11·5	2·09	1·74
	96·3		

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[*] Kong. Vet. Acad. Handl., 1824, p. 388, or Annals of Philosophy (2d series), xii. 117.

[†] Ann. des Mines (2d series), iii. 233.

The resulting constitution from the preceding analysis, is

3 atoms titaniate of zirconia,
2 atoms titaniate of iron,
$1\frac{3}{4}$ atoms dititaniate of yttria,
1 atom dititaniate of lime,
$\frac{1}{2}$ atom dititaniate of cerium,
$\frac{1}{2}$ atom dititaniate of manganese.

But the analysis would require repetition, in order to determine which of the constituents were lost during the process.

GENUS XIV.—THORIUM.

Thorium has been known for so short a time, that it is not surprizing that very few mineral species containing it are yet discovered. Indeed, if we except Siberian pyrochlore, in which Wöhler has discovered it to the amount of 5 per cent., the only species known is the one in which *thorina* was originally discovered.

Sp. 1. *Thorite.*[*]

This mineral was discovered in syenite in the island of Löv-ön, situated near Brevig in Norway. It was discovered by the Rev. Mr. Esmark, son of Esmark the celebrated professor in the university of Christiania. Esmark sent a specimen to Professor Berzelius, who analyzed it, and detected in it a new substance, to which he gave the name of thorina.

Thorite is black.

Amorphous, without any indication of crystalline shape or cleavage. It resembles very closely the gadolinite of Ytterby. Sometimes its surface is covered with a thin coating of rust coloured matter. Streak reddish grey; powder brownish red.

Very easily frangible and full of rifts.

Lustre of the fresh fracture vitreous, of the old surfaces resinous and dull.

Easily scratched by the knife; opaque.

Specific gravity 4·63.

Before the blowpipe it loses its black colour, gives out water, and becomes pale brownish red. It does not fuse.

Calcined in a tube, it gives out slight indications of fluoric acid. With borax it fuses easily; and when the assay is added in considerable abundance, the bead becomes opaque on cooling, but by flaming recovers its transparency. The bead has the usual colour imparted by iron. The addition of nitre shows the presence of manganese. With biphosphate of soda it dissolves, leaving a skeleton of silica; the glass, which is coloured by iron, becomes opaline in cooling. With carbonate of soda the mineral is decomposed without fusion, and a yellowish brown scoria remains on the charcoal. When borax is added, small metallic grains are obtained, which flatten under the pestle. When heated with carbonate of soda on platinum foil, the whole becomes green coloured.

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[*] *Kong.* Vet. Acad. Handl., 1829, p. 1.

The constituents, by Berzelius's analysis, are as follow:

		Atoms.
Thorina,	57·91	6·81
Silica,	18·98	9·49
Lime,	2·58	0·73
Peroxide of iron,	3·40	0·68
Oxide of manganese,	2·39	0·48
Magnesia,	0·36	0·14
Peroxide of uranium,	1·61	0·57
Oxide of lead,	0·80	0·05
Oxide of tin,	0·01	
Water,	9·50	8·44
Potash,	0·14	
Soda,	0·10	
Alumina,	0·06	
Powder not dissolved,	1·70	
	99·54	

If we consider the silica as the only acid, and all the other constituents as bases, the mineral will be composed of simple silicates, and its constitution is very nearly

2 atoms silicate of thorina,
1 atom silicate of lime, iron, manganese, &c.
1¼ atom water.

But it is probable that several of the constituents are only accidentally present.

GENUS XV.—IRON.

Iron is scattered in such profusion through almost every part of the globe, that but few minerals exist which do not contain some trace of it. But we include under this genus those minerals only which consist chiefly of it, or which at least contain it as an essential and notable constituent. These minerals are so numerous that *iron*, after alumina, is the richest in species of any genus at present known. They may be divided into three sections. The first consists of those species in which iron either exists uncombined, or in combination with a simple substance. The species belonging to the second section consist of oxide of iron, united to an oxygen acid; while the third section embraces those species in which a sulphuret of iron is united with a sulphur acid.

Sect. 1. *Iron uncombined, or united to a simple substance.*

The species belonging to this section amount to about 12, and they constitute some of the most abundant and important ores of this metal.

Sp. 1. *Native Iron.*

Bolide.

It is still a question among mineralogists whether native iron really occurs. There is no doubt, however, that specimens of it have been occasionally met with. Cramer describes one found in the mine of Hackenburgh, weighing four lbs.* Charpentier, in his Mineralogical Geography of Saxony, mentions a specimen found at Kamsdorf, in Saxony. Klaproth had in his cabinet a specimen from the mine Eiserner Johanness, at Great Kamsdorf, which he subjected to chemical analysis.† Specimens of native iron were found in veins at Canaan, in Connecticut. These veins pass through a quartz rock. It is said to occur in the same place in thin beds in mica slate. Some of the specimens found weighed 8 ounces.‡

Colour bluish-white.

Fracture hackly; cleavage none.

Lustre metallic; malleable.

Hardness 4·5.

Attracted by the magnet.

The specific gravity of the specimens found in Connecticut varied from 5·95 to 6·72.

The constituents of the specimen analyzed by Klaproth were

Iron, .	92·5
Lead, .	6·0
Copper, .	1·5
	100·0

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* *Phil. Mag.* xiii. 32. † Gehlen's Jour. i. 34.

‡ *Ann. des* Mines (second series), iii. 258.

It is not probable that these constituents could be chemically combined. The Connecticut specimens contained no foreign metal, but they were mixed with plates of plumbago, and associated with native steel.

Sp. 2. *Meteoric Iron.*

This species of iron is believed to have constituted a portion of those igneous meteors which occasionally make their appearance in our atmosphere, and after burning for some time, burst with a loud explosion. It does not therefore, strictly speaking, belong to the mineral bodies of which our globe is composed; but as it exists occasionally on the surface of the earth in large masses, which are applied to useful purposes, it would be improper to pass it over here.

The most remarkable specimens of meteoric iron are those discovered by Pallas in Siberia, and Rubin de Celis in South America. Masses of native iron have been found also in Mexico, in Peru, on the Andes, at the Cape of Good Hope, at Elbugen in Bohemia, Agram in Croatia, and in one of the islands on the north coast of America. From this last specimen, as we are informed by Captain Parry, the Esquimaux supply themselves with all the iron which they require.

Meteoric iron is silver-white, and not nearly so liable to rust as common iron. Its structure is granular, and its specific gravity 7·3.[*]

The following table exhibits the constituents of various specimens of native iron, according to the best analyses hitherto made:

	†	†	‡	‡	‡	‡
Iron,	96·5	98·5	91·51	91·23	91·76	90·76
Nickel,	3·5	1·5	8·59	8·21	6·36	7·87
	100	100	100·10	99·44	98·12	98·63

If these specimens be chemical compounds of iron and nickel, it is clear that the two metals combine in many various proportions. The specimen in the third column is a compound of

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[*] This was the specific gravity of native iron found on the Eastern Cordillera of the Andes. See Edinburgh Jour. xi. 120.

[†] Klaproth, Gehlen's Jour. i. 13. The first specimen from Sclavonia, the second from Siberia.

[‡] Mariano de Rivero, and Boussingault, Edin. Jour. xi. 120. The specimens analyzed were from the Eastern Cordillera of the Andes.

10 atoms iron,	35
1 atom nickel,	3·25
	38·25

Sp. 3. *Magnetic Iron Ore.*

Octahedral iron ore—oxidulous iron—ferroso ferric oxide.

This mineral occurs in beds or in single crystals imbedded in chlorite slate, serpentine, greenstone, &c. The beds often extend a great way both in length and thickness. Hence magnetic iron ore constitutes one of the most abundant and important ores of that metal.

Colour iron black; streak black.

Massive and crystallized. Primary form the regular octahedron. Frequently all the edges of the octahedron are replaced by tangent planes. When these secondary faces become so much enlarged as to efface the primary planes, the crystal assumes the form of the rhombic or garnet dodecahedron.

Cleavage sometimes perfect, parallel to the faces of the primary octahedron, sometimes not to be observed.

Fracture conchoidal, uneven.

Lustre metallic; but sometimes imperfect.

Opaque; brittle.

Hardness 5·5 to 6·5; specific gravity of a very pure specimen 5·092, by my trial.

Not altered before the blowpipe per se. With borax in the oxidizing flame it fuses into a dull-red glass, which becomes clear on cooling, and often assumes a yellow tint. In the reducing flame it becomes bottle-green. The same appearances are produced with biphosphate of soda. Does not fuse with carbonate of soda.

Berzelius first showed that magnetic iron ore is a compound of

1 atom protoxide of iron, .	4·5
2 atoms peroxide of iron, .	10·0
	14·5

His results were confirmed by the analysis of a very pure specimen in my laboratory by Messrs. Mitchell and Hilton. 25 *grains of the mineral* yielded them

Peroxide of iron, .	25·432
Silica, . . .	0·4
	25·832

The excess was owing to the conversion of the protoxide of iron in the specimen to peroxide. The silica was doubtless foreign matter mechanically mixed with the pure ore. It will be found on calculation, that in magnetic iron ore, 1 atom of iron is combined with 1⅓ atom oxygen, which gives the very constitution pointed out by Berzelius.

Magnetic iron ore occurs most commonly in primary formations. Hence its abundance in Scandinavia. It is from it that all the Swedish iron, so celebrated for its excellent qualities, and so fit for steel, is extracted.

Sp. 4. *Specular Iron Ore.*

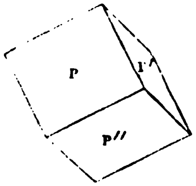
Anhydrous peroxide of iron, oligiste iron, iron froth, iron mica, red hematite, red clay ironstone, red siliceous ironstone, red ochre.

This mineral occurs usually in beds and veins in primary formations. It is found crystallized in the lava ejected from Vesuvius. Beautiful crystals occur in Elba along with iron pyrites and quartz. It is found also in many other places.

Colour in the perfect specimens steel-grey and iron-black. When the state of aggregation is lost, the mineral becomes red.

Lamelliform, and crystallized in a great variety of forms. The primary form is a slightly acute rhomboid.

P on P′ 86° 10′
P on P″ 93° 50′



Sometimes the mineral assumes the form of an octahedron, sometimes of a triangular dodecahedron, with its apices truncated either very deep or near the apex. The common shape of the crystal from Elba is rather complicated. For a description we refer to Hauy or Phillips.

Lustre metallic.

Opaque; very thin laminæ are faintly translucent. They show a deep blood-red colour.

Brittle; sometimes acts feebly on the magnet.

Hardness 5·5 to 6·5; specific gravity of a crystallized specimen from Sweden, as determined by Haidinger, 5·251.

Before the blowpipe it behaves like magnetic iron ore.

When pure it consists entirely of peroxide of iron.

The *micaceous* variety of this species occurs massive or crystallized in thin six-sided tables. It usually consists of thin plates, which held between the eye and the light appear blood-red. In other respects it is similar to the common specular iron ore. Sp. gr. 4·491 to 5·059, according to Kirwan.

Iron froth (Eisenrahm) is composed of scaly friable parts, which soil strongly; colour between cherry and brownish-red; very soft. It was analyzed by Dr. Henry, who obtained

Peroxide of iron, .	94·5
Silica? . . .	4·25
Alumina, . . .	1·25
	100

Red hematite (Rothglaskopf) is found in masses, stalactites and kidney-form balls; colour brownish red; powder red; structure fibrous; specific gravity of a specimen from Muirkirk 6·305; hardness 7; opaque; lustre semimetallic. I subjected it to analysis, and obtained

Peroxide of iron, .	96·65
Columbic acid? .	1·45
Alumina, . .	0·79
Water, . . .	1·09
	99·98

Compact red iron ore occurs massive or in pseudomorphous cubic crystals; colour brown red; fracture uneven; texture compact. Sp. gr. 4·232, as determined by Hoffmann.

The *red lenticular clay-iron stones* belong also to this species. They consist of red oxide of iron more or less mixed with foreign matter.

Red ochre and *reddle* also belong to it.

Sp. 5. *Crucite.*

The singular mineral to which I have given this name is found disseminated in purple coloured clay slate at Clonmell, in the County of Waterford, in Ireland. It was brought me by Mr. Doran, who, I presume, was the person who first found it.

It is always in crystals. The shape is a four-sided oblique prism, the faces of which meet at angles of 60° and 120°. These crystals are about an inch in length, and about one-fifth of an inch in thickness. Two of them always occur together crossing each other at angles of 60° and 120°. Hence the reason of the name by which I have distinguished it. Sometimes three crystals cross each other constituting a kind of star with six rays. Each of the angles at the centre where the crystals cross is an angle of 60°.

Internal colour black with something of the metallic lustre. Externally the colour is red, obviously from the action of the atmosphere. Does not act on the magnetic needle.

External lustre dull; opaque.

Hardness 3; specific gravity 3·579. That of another specimen was as high as 3·8095. But the quantity which could be employed for these determinations was so small that great accuracy is not likely to have been attained.

Before the blowpipe it acts precisely as oxides of iron do.

It was analyzed with great care by my nephew Dr. R. Thomson, but he found it impossible to exclude the whole of the matrix in which the crystals occur. The constituents obtained were

		Atoms.
Peroxide of iron,	81·666	16⅓
Alumina,	6·866	3
Silica and scales of mica,	6·000	3
Lime,	4·000	1·14
Magnesia,	0·532	0·21
	99·064	

It is impossible to draw any satisfactory conclusion from these numbers, because part of the constituents was certainly derived from the matrix. This matrix, examined by the magnifying glass, was so full of quartz grains that I am disposed to ascribe all the quartz to this source. If the alumina, lime, and magnesia be constituents of the mineral, which, however, is more than doubtful, it might be perhaps considered as composed of

2 atoms terferrate of alumina,
1 atom terferrate of lime.

The peroxide of iron acting the part of an acid.

The great difference between the specific gravity of crucite and of specular iron ore, makes it impossible to consider it as a variety of that mineral, even if the crystalline form were not incompatible.

I have placed it provisionally next in order after specular *iron ore,* till the discovery of purer crystals than we were able to pick out from the specimens of Mr. Doran, enable us to determine whether or not our present views respecting its chemical constitution be correct.

Sp. 6. *Manganesian Iron Ore.*[*]

This mineral was sent me by Mr. Nutall from Stirling, in Massachusetts.

Colour black; lustre splendent, semimetallic; streak red.

On some parts of the surface splendent facets appear, which seem to indicate an octahedron as the primary form of its crystals. Texture foliated, but cleaves only in one direction.

Surface smooth; brittle; opaque.

Hardness 7; specific gravity 5·079.

Fracture small conchoidal. This, together with the colour and lustre, gives the mineral something of the aspect of cherry coal.

Acts feebly on the magnetic needle, but has no polarity.

Its constituents, by my analysis, are

		Atoms.
Peroxide of iron, .	75·5	. 15·1
Sesquioxide of manganese,	22·65	. 4·53
Titanic acid with some iron,	1·15	
Moisture, . .	0·40	
	99·7	

This approaches

3 atoms peroxide of iron,
1 atom sesquioxide of manganese.

There is an excess of peroxide of iron which is probably united in the mineral with titanic acid.

Sp. 7. *Franklinite.*

This mineral exists in great abundance at Franklin, in Sussex county, New Jersey. It was analyzed and described by Berthier in 1819.[†]

Colour iron grey; powder dark brown.

Granular and massive. Found also in crystals. The shape is an octahedron, but all of them that I have seen have rough surfaces and cannot be measured. They are sometimes several inches in length.

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[*] I have a suspicion that this species and the following are only varieties of each other.

[†] *Ann. des Mines, iv. 483.*

Fracture conchoidal.

Lustre metallic.

Opaque; crystals semitransparent, and show a blood-red tint; brittle; not easily pounded.

Hardness 6 to 6·5; specific gravity of the pure crystals 5·069; pieces picked out of a mixture of franklinite and red zinc 4·257; Berthier states the specific gravity 4·87.

Acts sensibly on the magnetic needle, but does not adhere to the magnet, nor is it possessed of sensible polarity.

Its constituents are as follow:—

	*	†	Atoms.
Peroxide of iron,	66	66·10	13·22
Sesquiox. of manganese,	16	14·96	2·99
Oxide of zinc,	17	17·425	3·31
Silica,	—	0·204	
Water,	—	0·560	
	99	99·249	

These analyses very nearly coincide. Probably in neither was the oxide of zinc completely freed from all oxide of manganese. The numbers approach

4 atoms peroxide of iron,
1 atom sesquioxide of manganese,
1 atom oxide of zinc.

Were we to consider the peroxide of iron as acting the part of an acid, the constitution of the mineral might be represented thus,

1 atom biferrate of manganese,
1 atom biferrate of zinc.

Sp. 8. *Dihydrous Peroxide of Iron.*

A nodule of this mineral, about the size of a hen's egg, was found in a trap rock at Gourock, in the neighbourhood of Greenock. It occurs also in crystals at St. Just, in Cornwall, and with crystallized quartz at St. Vincent's rocks, near Bristol.

Colour reddish brown; streak lighter.

The nodule was composed of very fine needles, diverging slightly like a painter's brush. The crystals have a right rhombic prism for their primitive form.

The faces of the prism are inclined to each other at angles of 130° 40′ and 49° 20′. They cleave easily in the direction of the short diagonal of the base.

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* By Berthier's analysis.

† By my analysis. The specimen was very pure, and had been sent me by Dr. Torrey expressly for analysis.

Lustre imperfect metallic and silky, that of the crystals adamantine.

Brittle; opaque.

Hardness 4·5; specific gravity 4·375.

The constituents, determined by my analysis, are

			Atoms.
Peroxide of iron,	91·7	18·34	1
Water,	8·5	7·55	0·41
	100·2		

The water is rather less than half an atom. Doubtless a little of it had made its escape before the nodule was subjected to analysis. In the crystals the proportion of water was very nearly half an atom.

Sp. 9. *Hydrous Peroxide of Iron.*

Stilpnosiderite, bonerz, brown fibrous hematite, brown ochre, brown clay ironstone, gothite, lepidokrokite, pyrosiderite, rubinglimmer, umber, yellow clay ironstone.

This species occurs both in beds and veins in primary as well as secondary rocks, and is very abundant.

Colour various shades of brown, as yellowish brown, hair brown, clove brown, and blackish brown; streak yellowish brown.

Massive. It is said also to occur crystallized, but I suspect that all the crystals hitherto described belong to the last species. Those of St. Just I analyzed and found to be in that predicament.

Opaque; does not act on the magnet.

Hardness 4·5 to 5; specific gravity of the crystals from St. Just 4·04. Haidinger states the specific gravity 3·922.

The *fibrous brown iron ore* or *brown hematite* constitutes the true type of the species. In the compact brown ore the structure of the species is no longer visible, though the constituents are still firmly compacted together. The *lenticular clay ironstone*, the *kidney form* or *etites*, and the *pisiform iron ore*, and *brown iron ochre* are to be considered as impure varieties.

The following table exhibits the constituents of the different varieties:—

	*	†	†	†	†	†	†	†	†
Peroxide of iron, .	80·50	79	72	84	81	78	73	76	83
Sesquiox. of mangan.,	trace	2	2	1	—	trace	1	2	trace
Water, . .	16·00	15	14	11	12	13	14	14	12
Silica, . .	2·25	3	1	2	4	6	9	5	5
Alumina, . .	—	—	trace	—	—	1	—	—	—
	98·75	99	99	98	97	99	97	97	100

The first three specimens analyzed exhibit the species in its state of greatest purity. The mean of them gives

		Atoms.
Peroxide of iron, . .	80·5 .	16·1
Sesquioxide of manganese,	1·3 .	0·26
Water, . . .	15·0 .	13·34
Silica, . . .	2·08 .	1·04

If we admit the silica to be united with peroxide of iron in the state of disilicate, or rather trisilicate, and to be accidental, it is obvious that the mineral is a hydrous peroxide of iron, composed of

1 atom water,
1 atom peroxide of iron.‡

Sp. 10. *Magnetic Pyrites.*

Sulphuret of iron.

This species occurs in beds along with other minerals containing iron. It also forms an accidental ingredient in several rocks, and crystallizes in their fissures. In this way it occurs in Cornwall, Wales, at the base of Moel Elion, in Caernar-

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* Ulmann, Hoffman's Miner., iv. 188. The specimen was stilpnosiderite.

† D'Aubuisson, Ann. de Chim., lxxv. 237. The first two specimens brown hematites. The third and fourth compact brown hematites. The fifth and seventh etites. The sixth lenticular iron ore. The eighth brown ochre.

‡ The variety called ligniform hematite, from some resemblance which it bears to wood, has a brown colour, a fibrous texture, and a specific gravity of 3·443. I analyzed a specimen and obtained

		Atoms.
Silica, . . .	1·80 .	0·9
Peroxide of iron, .	78·80 .	15·76
Alumina, . .	1·48 .	0·65
Water, . .	16·60 .	14·75
	98·68	

If we leave out the alumina as accidental, the constituents are

16 atoms perhydrate of iron,
1 atom persilicate of iron.

vonshire, and in some of the hills of Galloway. Crystals of it are found in Bodenmais, in Bavaria, and at Breitenbrun and Geyer, in Saxony.

Colour intermediate between bronze-yellow and copper-red; streak dark greyish-black.

It occurs most frequently massive, but Count Bournon informs us that it is found also crystallized in irregular six-sided prisms, variously modified. It affords, by cleavage, the regular six-sided prism, which is therefore its primary form.

Lustre metallic; opaque; brittle.

Hardness 5 to 6; Specific gravity 4·631.

Acts slightly on the magnetic needle.

Its constituents have been found as follow:

Iron,	63·5	59·85	56·37
Sulphur,	36·5	40·15	43·63
	100†	100‡	100‡

There are two sulphurets of iron, which have been long known to chemists; namely, the sulphuret composed of 1 atom sulphur and 1 atom iron, and the bisulphuret composed of two atoms sulphur and one atom iron.

If we consider the three analyses given in the table to be accurate, the specimens analyzed must be composed as follow:

			Atoms.
1st, of	Sulphuret of iron,	99·199	180
	Bisulphuret of iron,	0·801	1
		100	
The 2d, of	Sulphuret of iron,	77·688	5
	Bisulphuret of iron,	22·312	1
		100	
The 3d, of	Sulphuret of iron,	57·175	2
	Bisulphuret of iron,	42·825	1
		100	

They constitute, in fact, three distinct species, although we have no adequate means of distinguishing them by their external characters.

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† Hatchett, Phil. Trans. 1804, p. 315.

‡ Stromeyer, Gilbert's Annalen, xlviii. 183. The specimens were from *the Hartz. The first analysis* corresponded with the constitution of magnetic *pyrites made artificially.*

Sp. 11. *Bisulphuret of Iron.*

Iron or cubic pyrites, mundic, sulphur.

This species is almost universally diffused. It occurs in clay slate, both in isolated crystals and in beds. In greenstone and granular limestone it exists in massive nodules. It is a pretty abundant ingredient in coal beds, and often contaminates the coal; being known to colliers by the name of *sulphur.* It frequently accompanies ores of zinc, lead and copper.

Colour a characteristic bronze-yellow, varying a little in shade; streak brownish-black.

Massive and crystallized in cubes and regular octahedrons, and in figures derived from these forms, as the pentagonal dodecahedron and the icosahedron. The cube has been adopted as the primary crystal, because the mineral cleaves best parallel to its faces.

Fracture conchoidal; opaque; lustre metallic.

Hardness 6·5; specific gravity from 4·830 to 5·031.

The following table exhibits the constituents of this mineral, according to the best analyses hitherto made:

	[*]	[*]	[*]	[†]
Sulphur, .	52·15	52·5	52·7	54·26
Iron, . .	47·85	47·5	47·3	45·74
	100	100	100	100

If we calculate the constitution of the mineral from Berzelius's analysis, we have:

		Atoms.
Sulphur, .	27·13 .	2·07
Iron, . .	13·06 .	1

The mean of Hatchett's analyses gives:

		Atoms.
Sulphur, .	26·22 .	1·93
Iron, . .	13·58 .	1

The mean of the two gives us:

Sulphur 2 atoms,
Iron 1

There cannot therefore be the least doubt about the true constitution of this mineral.

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[*] Hatchett, Phil. Trans. 1804, p. 325. The first specimen was in pentagonal dodecahedrons, and had a specific gravity of 4·830. The second was in striated cubes; the third in smooth cubes, and had a specific gravity of 4·831.

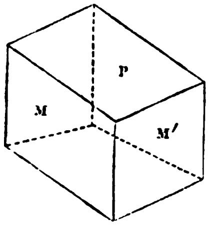
[†] Berzelius.

Sp. 12. *Radiated Pyrites.*

White bisulphuret of iron, cockscomb pyrites, kamkies, leberkies, zelkies.

This species is much less abundant than the preceding. It occurs most commonly in coal beds. It is found also in veins along with ores of silver, lead and copper.

Colour pale bronze yellow, sometimes inclining to green or grey; streak greyish black.



Massive and crystallized. The primary form is a right rhombic prism,

M on M′ 106°

But the most common form is a very flat crystal, having at first sight the appearance of a dodecahedron, with triangular faces, but consisting in fact of similar portions of five crystals connected together.

Lustre metallic; opaque; brittle.

Hardness 6; specific gravity from 4·678 to 4·847.

Its constituents, as determined by Hatchett and Berzelius, are as follow:

Iron,	46·40	45·66	45·07
Manganese,	—	—	0·70
Sulphur,	53·60	54·34	53·35
Silica,	—	—	0·80
	100*	100*	99·92†

The constitution is obviously the very same as that of the preceding species. This is remarkable, as the two species differ in their specific gravity, and in the shape of their crystals.

Sp. 13. *Sesquiarseniet of Iron.*

This mineral was first distinguished as a peculiar species by Mohs, under the name of *axotomous arsenical pyrites*.‡ Hitherto it has been found only in beds either along with sparry iron ore, or imbedded in serpentine. In the first way it occurs in the valley of Löling, near Huttenberg, in Carinthia; in the second way at Reichenstein, in Silesia.

Colour between silver-white and steel-grey.

It is found crystallized, and its primary form, according to Mohs, is an octahedron, whose faces are scalene triangles, and whose axes are to each other as $1 : \sqrt{0\cdot8747} : \sqrt{0\cdot4806}$

Fracture uneven; brittle; lustre metallic; opaque.

Hardness 5 to 5·5; specific gravity of the massive variety from Reichenstein, 7·228.

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* *Hatchett, Phil. Trans.* 1804, p. 325. † Berzelius, Mineralogie, p. 263.

‡ Mohs' Mineralogy, ii. 448.

Its constituents, as determined by the analysis of Hoffmann,* are:

		Atoms.	
Sulphur,	1·94	0·97	0·12
Arsenic,	65·99	13·89	1·72
Iron,	28·06	8·01	1
Serpentine,	2·17		
	98·16		

If we allow the sulphur to be united to arsenic, and to be only accidental, it is obvious that the constitution of the mineral is

1½ atom arsenic,
1 atom iron.

It is therefore a sesquiarseniet of iron.

Sect 2. *Oxygen Salts of Iron.*

These salts being numerous, for they amount to no fewer than 48 species, it will be convenient to subdivide them.

I. *Simple Oxygen Salts.*

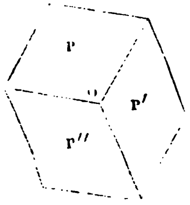
These constitute more than half of all the oxygen salts of iron, but the simplicity of their constitution renders it easy, in a chemical point of view, to distinguish them from each other.

Sp. 1. *Carbonate of Iron.*

Brownspar, stahlstein, spherosiderite, spathose iron, fer spathique, clay ironstone, argillaceous iron ore.

This species occurs frequently in veins along with ores of lead and copper, and is rather abundant in the contemporaneous veins of primary rocks. Great beds of it occur in our coal formations, which supply all the ore requisite for the immense quantity of iron annually smelted in Great Britain.

Colour various shades of yellowish-grey, passing into ash, and greenish-grey, also into several shades of yellow, white, and red. The clay ironstone is sometimes black, from the carbonaceous matter which it contains; streak usually white.



Massive and crystallized in obtuse rhomboids, approaching pretty nearly to the shape of the primary crystal of calcareous spar.

P on P′ 107°
P or P′ on P″ 73°

according to the measurements of Dr. Wollaston.

Sometimes the angle o is replaced by

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* Poggendorf's Annalen, xxv. 489.

three planes, which, increasing in size, form a kind of elongated double three-sided prism, terminated by the half of the original rhomboid.

Not unfrequently the lateral angles of the rhomboid are replaced by tangent planes, which converts the crystal into a regular six-sided prism. Very large crystals of this shape have been found in Cornwall.

Fracture imperfect conchoidal.

Lustre vitreous, inclining to pearly.

Translucent to opaque; brittle.

Hardness 3 to 4·5; specific gravity from 3·7317 to 3·829.

Before the blowpipe it blackens, giving off carbonic acid, and leaves an oxide of iron very attractable by the magnet.

The first attempt to analyze *sparry iron ore*, as this species was called, was by Bergman, but his results were too inaccurate to induce confidence. Drappier analyzed three specimens in the year 1803, and found them composed of protoxide of iron, magnesia, and carbonic acid.[*] Soon after two other specimens were analyzed by Collet Descotils, with nearly the same result.[†]

The following table shows the constituents, according to the most recent analyses hitherto made:—

	‡	‡	§	‖
Protoxide of iron,	57·5	58	54·57	52·128
Protox. of mangan.,	3·5	4·25	1·155	—
Lime, . .	1·25	0·50	3·176	9·965
Magnesia, .	—	0·75	—	
Alumina, .	—	—	—	5·676
Moisture, .	—	—	2·630	—
Carbonic acid, .	36·0	35	35·900	32·231
	98·25	98·5	97·431	100

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[*] Jour. des Mines, xviii. 47.

[†] Ibid. p. 211.

[‡] Klaproth, Beitrage, iv. 110. The first specimen was from Dankerode, in Halberstadt; the second from Bareuth.

[§] By my analysis. The specimen was from Slitt lead mine, in the county of Durham. It exists in considerable quantity in the gangue of the ore, and is granular, and of a reddish-white colour, and has a specific gravity of 3·7317.

[‖] Bischoff, Ann. des Mines (second series), i. 279. It was a *spherosiderite.*

It is obvious that the mineral consists essentially of carbonate of iron, composed of

1 atom carbonic acid,
1 atom protoxide of iron;

but there are generally present carbonates of lime and magnesia, in more or smaller quantity.

The important metallurgical ore called *clay ironstone*, is in reality a mixture of carbonate of iron with clay, and sometimes with carbonaceous matter. Hence the variety of colour which it exhibits.

The fracture is usually earthy; the mineral is opaque, and has a specific gravity which varies from 2·936 to 3·471. The following table exhibits the specific gravity of several varieties of clay ironstone, from the coal beds in the neighbourhood of Glasgow, as determined by Dr. H. Colquhoun.

Localities.		Specific gravity.
Crossbasket,		3·1793
Do.	greyish-black,	3·3801
Do.	light greyish black,	3·2699
Do.	brownish-black,	3·1175
Clyde Iron Works,		3·1482
Do.	do.	3·2109
Easterhouse,		3·3109
Airdrie, Mushet's black band,		3·0553

The following table exhibits the composition of these specimens, as determined by the analysis of Dr. Colquhoun:*

Carbonic acid,	32·53	33·63	31·86	30·76	26·35	33·10	32·24	35·17
Protoxide of iron,	35·22	45·84	42·15	38·80	36·47	47·33	43·73	53·03
Protox. of mangan.,	—	0·20	—	0·07	0·17	0·13	—	—
Lime,	8·62	1·90	4·93	5·30	1·97	2·00	2·10	2·33
Magnesia,	5·19	5·90	4·80	6·70	2·70	2·20	2·77	1·77
Silica,	9·56	7·83	9·73	10·87	19·20	6·63	9·70	1·40
Alumina,	5·34	2·53	3·77	6·20	8·03	4·30	5·13	0·63
Peroxide of iron,	1·16	—	0·80	0·33	0·40	0·33	0·47	0·23
Coaly matter,	2·13	1·86	2·33	1·87	2·10	1·70	1·50	3·03
Sulphur,	0·62	—	—	0·16	—	0·22	0·02	—
Moisture,	—	0·99	—	—	—	—	—	—
	100·37	100·68	100·37	101·00	98·09	97·94	97·66	98·59

The following table exhibits the analyses of nineteen varieties of clay ironstone occurring in nodules or beds in the coal beds of France:

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* Brewster's Journal, vii. 234.

	Magescote.	Barthes.	Gabliers.	Baumer.	Fine.	Vescheres.	Morillon.	Mouillar.	Do.	Do.	Do.	Do.	St. Etienne.	Do.	Do.	Do.
Protoxide of iron,	35	51	43·9	54·2	37·3	13·5	20·3	28·5	45·0	40·0	38·0	46·7	41·8	50·8	38	41·2
Protoxide of mangan.	0·3	1·5	0·2	1·1	1·7	0·3	0·6	1·1	2·9	1·5	1·4	2·8	4·1	1·0	2·5	1·0
Magnesia, . . .	1·6	—	2·0	0·9	1·9	0·8	0·3	5·0	—	3·0	2·6	—	0·2	—	1·5	3·0
Lime, ...	—	1	—	0·3	6·0	7·4	4·2	3·0	0·3	—	—	2·4	0·2	3·5	13·0	8·0
Loss by calcination,	25·5	29·5	30·5	28·9	27·7	24·6	21·9	21·0	25·7	14·6	9·1	32·5	38·4	31·6	42·2	21·4
Silica, ...	26·5	9·0	10·2	12·8	25·0	47·1	47·4	35·7	18·9	35·7	44·4	11·4	12·3	10·3	—	18·2
Alumina, . . .	11·8	7·0	13·0	1·8	0·9	6·3	3·3	6·5	6·1	5·5	4·4	2·9	3·2	2·8	2·0	2·0
Phosphoric acid,	—	—	—	—	—	—	—	0·3	—	—	—	—	—	—	0·8	6·1
	100·7	99	99·8	100	100·5	100	98	100·9	98·9	100·3	99·9	98·7	100	100	100	100·9

These analyses and many others were made by Berthier. See his *Traité des Essais par la voie seche*, vol. ii. p. 252.

It is obvious from an inspection of these analyses, that all the specimens examined, were mixtures of

Carbonate of iron,
Carbonate of lime,
Carbonate of magnesia,
Pyrites,
Clay,
Coal,

in various proportions. Thus the first specimen consisted of

Carbonate of iron,	55·697
Carbonate of lime,	15·390
Carbonate of magnesia,	10·899
Clay, . . .	16·060
Pyrites, . .	1·125
Coaly matter, .	2·130
	101·301

The excess is owing to the deficiency of carbonic acid in the analysis. The quantity necessary to saturate the protoxide of iron, lime, and magnesia, in the specimen, is 33·605 grains, while only 32·53 grains were obtained.

Mushets black band is the specimen which contains the greatest quantity of carbonate of iron. It is composed of

Carbonate of iron, .	85·437
Carbonate of lime, .	5·946
Carbonate of magnesia, .	3·317
Clay, ...	2·260
Coaly matter, . .	3·030
	99·99

In this analysis also there is a loss of 1·4 grain of carbonic acid, provided the whole of the protoxide of iron, lime, and magnesia be saturated with that acid, as is very probably the case. None of the French specimens, analyzed by Berthier, is so pure as Mushet's black band. I analyzed a specimen of ironstone from the neighbourhood of the Monkland canal, which contained 80·2 per cent. of carbonate of iron.

Its specific gravity was 3·505. Next to Mushet's black band, it is the purest specimen of clay ironstone that I have ever met with.

Sp. 2. *Junkerite.*

This mineral has been lately discovered in the mine of Poullaouen, in a gallery of research opened in the pit Kœnig. It covers the surface of small quartz veins which traverse the grey wacke of the locality. M. Paillette, sub-director of the mine, discovered the crystals constituting this species, and gave them the name of Junkerite, in honour of the director, M. Junker, to whom the mine is indebted for its present state of activity.

Colour yellowish grey, not unlike that of some varieties of tungstate of lime.

It is in crystals, the usual form of which is a rectangular octahedron, the faces of which are curved somewhat like those of the diamond. The faces of the octahedron are dull, so that the angles cannot be measured by the reflecting goniometer. But it possesses three cleavages, which bring into view new faces of such brilliancy, that the angles admit of easy measurement. Two of these cleavages are parallel to the diagonal planes of the octahedron, and consequently meet at an angle of 108° 26′. The third cleavage is perpendicular to the axis of the octahedron. Hence the primary form is a right oblique prism, the faces of which meet at angles of 108° 26′, and 71° 34′. The two vertical cleavages always occur, but the third only occasionally.

The common carbonate of iron which constitutes the preceding species, has for its primary form an obtuse rhomboid with angles of 107°. A form quite incompatible with the present. Thus common carbonate of lime and Junkerite differ from each other precisely as calcareous spar and arragonite differ. Calcareous spar has for its primary form an obtuse rhomboid of 105° 5′, while that of arragonite is a right oblique prism, the faces of which meet at angles of 116° 10′, and 63° 50′.

Hardness 3·5; specific gravity 3·815.

Before the blowpipe with borax it fuses into a yellowish green glass, which becomes brown when the proportion of Junkerite is considerable.

The constituents of this mineral, determined by two different analyses of M. Dufresnoy, to whom we owe the only description hitherto published, are as follow:

Protoxide of iron, .	53·6 .	47·9
Carbonic acid, .	33·5 .	30·0
Silica, . .	8·1 .	16·8
Magnesia, . .	3·7 .	3·9
	98·9	98·6*

If we admit the silica to be accidental, as can hardly be doubted from the great difference in the two analyses, there is a slight excess of bases. The atoms of acids and bases being

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* *Ann. de Chim.* et de Phys. lvi. 198.

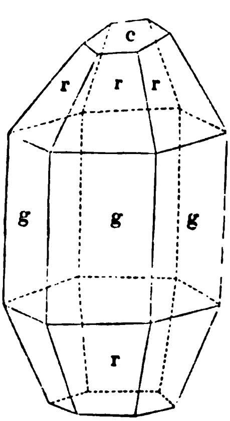
		By 1st analysis.		By 2d analysis.
Carbonic acid, . .		12·1 atoms		10·64
Protoxide of iron,	11·91	13·3	10·64	12
Magnesia, .	1·4		1·4	

But we have no evidence that the mineral was not a neutral carbonate of iron, as M. Dufresnoy did not determine the weight of the carbonic acid evolved, but deduced it simply from the quantity of protoxide obtained.

Sp. 3. *Bisulphated Peroxide of Iron.*

This mineral was brought from South America by Dr. Meyen. It is found in the province of Coquimbo, the most northerly part of the republic of Chili, not far from the boundary of the province of Bolivia, and about half a day's journey from the town of Copiapo. It constitutes a bed in a felsparry rock, which fuses before the blowpipe. This rock agrees with a fine grained granite in its properties. It is probable that the salt is derived from the decomposition of a bed of iron pyrites situated in the rock. The bed of salt rises in various places to-day, and pits almost 20 feet deep have been dug in it by the country people.

The salt is white, and partly in fine granular masses and partly in crystals. These crystals have the figure in the margin, a regular six-sided prism, terminated at both extremities by a truncated six-sided pyramid. The following are the angles calculated by M. H. Rose, from some measurements by his brother:



r on r	128° 8′
r on c	151
r on g	119
g on g	120

The crystals cleave imperfectly parallel to the faces r and g. Their fracture is conchoidal.

The salt is completely soluble in water, and when the solution is heated, a copious precipitate of peroxide of iron falls. When it is dissolved in water containing muriatic acid, a portion of silica remains undissolved.

From the analysis of Mr. H. Rose,[*] the constituents of this salt are

		Atoms.
Silica, .	0·31 .	0·15
Sulphuric acid,	43·55 .	8·71
Peroxide of iron,	24·11 .	4·82
Alumina, .	0·92 .	0·40
Lime, .	0·73 .	0·20
Magnesia, .	0·32 .	0·13
Water, .	30·10 .	26·75
	100·04	

As the salt is soluble in water, it is clear that all the bases must be combined with sulphuric acid. If we admit the alumina, lime, and magnesia, to be in the state of sulphates, as is most probable they will, for saturation require 0·73 atom of sulphuric acid. There will remain 8 atoms to unite with 4·82 atoms peroxide of iron. It is pretty clear from this that the salt is in the state of a bisulphate, or a compound of

2 atoms sulphuric acid,
1 atom peroxide of iron,
5 atoms water,

These numbers must represent very nearly the constitution of the salt.

Sp. 4. *Sulphated Peroxide of Iron.*

This salt is generally found encrusting the preceding. It consists of small grains frequently covered with small thin six-sided tables, so minute that their angles cannot be determined. Easily cleavable parallel to the surface of the table.

Colour yellow; translucent; lustre pearly. It is mixed with a good deal of siliceous matter which is not easily separated. Its constituents, according to the analysis of H. Rose,[†] are

		Atoms.
Silica, . .	1·37 .	0·68
Sulphuric acid,	39·60 .	7·92
Peroxide of iron,	26·11 .	5·22
Alumina, .	1·95 .	0·86
Magnesia, .	2·64 .	1·05
Water, .	29·67 .	26·37
	101·34	

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[*] *Poggendorf's Annalen*, xxvii. 310.

[†] Ibid. p. 314.

The alumina and magnesia were doubtless in combination with the sulphuric acid. They amount together to 1·91 atoms. This subtracted leaves 6·01 atoms of sulphuric acid to combine with 5·22 atoms of peroxide of iron These numbers approach so near equality, that we may consider the salt as composed of

1 atom sulphuric acid,
1 atom peroxide of iron,
5 atoms water.

Mixed with this salt there occurs a small quantity of a dirty yellowish green matter not crystallized, but forming small balls composed of short excentric rays two or three lines in length, very loosely connected together. When mixed with cold water, this salt is decomposed and deposites peroxide of iron. Its constituents, according to H. Rose,* are

		Atoms.
Silica,	1·43	0·71
Sulphuric acid,	31·73	6·33
Peroxide of iron,	28·11	5·62
Lime,	1·91	0·54
Magnesia,	0·59	0·21
Water,	36·56	32·5
	100·53	

The lime and magnesia amount together to 0·75 atom. If they were united to sulphuric acid, there will remain 5·58 atoms of that acid to combine with 5·62 atoms of peroxide of iron. These numbers are so near equality, that we cannot doubt that the salt is a neutral sulphated peroxide. The water combined with one atom of the salt is 5·78 atoms. The difference between this salt and the preceding, consists chiefly in this excess of water, which however does not amount to so much as an atom.

Sp. 5. *Mullicite.*†

This mineral was brought many years ago from the Isle of France and from Brazil, and was analyzed by Laugier and Cadet. I do not know whether the specimens from Bodenmais in Bavaria, analyzed by Fouveroy and Laugier,‡ and by

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* Poggendorf's Annalen, xxvii. 316.

† From Mullica Hill, where the mineral was found.

‡ Ann. de Mus. d'Hist. Nat. iii. 405.

Vogel,* belong to this species; but from the analyses, I think it is probable they do. The specimens in my possession are from the United States. They were found at Mullica Hill, Gloucester County, New Jersey. They consist of cylinders about two inches long and half an inch in diameter, encrusted with a yellowish red sand, which also occurs interspersed through the cylinders; thus giving them the appearance of having been formed in loose sand. The sand consists of grains of quartz, deeply tinged on the surface with oxide of iron.

Colour bluish black; lustre splendent and vitreous, and each cylinder consists of a congeries of small needle-form crystals radiating from the centre of the cylinder.

Opaque; sectile.

Hardness 1; specific gravity 1·787. The specimen was not free from grains of sand, and it doubtless contained small cavities between the crystals, though they could not be distinguished by the naked eye.

I found its constituents to be

		Atoms.	
Phosphoric acid,	24	5·33	1
Protoxide of iron,	42·65	9·47	1·67
Water,	25·00	22·22	4·16
Grains of quartz sand,	7·90		
	99·55		

These numbers approach very nearly to

1 atom phosphoric acid,
1⅔ atom protoxide of iron,
4 atoms water.

Probably the true composition is

1 atom phosphoric acid,
2 atoms protoxide of iron,
4 atoms water.

This would make it a diphosphate of iron.

The *diphosphate of iron* from Haute Vienne, analyzed by Vauquelin, is nearly allied to this species, but it contains less water, and a little phosphate of manganese.

It has a brown colour, and is crystallized in radiating needles. Its powder has an olive colour. Fuses before the blowpipe into a black glass. Its constituents, as determined by Vauquelin, are

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* Gilbert's Annalen, lix. 174.

			Atoms.
Phosphoric acid,	24·8	5·51	1
Protoxide of iron,	51·0	11·33	2·05
Protoxide of manganese,	9·0	2·00	0·36
Water,	15·0	13·33	2·4
	99·8		

It is very nearly 1 atom of diphosphate of iron (neglecting the manganese), and 2½ atoms water.

According to Berthier's analysis,* the constituents are

		Atoms.
Phosphoric acid,	28·82	6·4
Protoxide of iron,	56·67	12·59
Water,	14·51	12·9
	100·00	

This obviously gives us

1 atom phosphoric acid,
2 atoms protoxide of iron,
2 atoms water.

To this mineral the name of Anglarite has been given, from Anglar, the place where it is found.

Sp. 6. *Subsesquiphosphate of Iron.*

Blue iron earth. Native Prussian blue.

This mineral occurs in nests among the strata of bog iron ore, and in mosses.

It is a powder composed of earthy particles. At first its colour is greyish-white, but when exposed to the air it gradually acquires a smalt blue colour.

Soils slightly; feels harsh.

Before the blowpipe becomes reddish brown, and melts into a black brilliant globule, attracted by the magnet.

Its constituents, according to the analyses of Klaproth† and Brandes,‡ are

	†	‡	Mean.	Atoms.
Phosphoric acid,	32	30·32	31·15	1
Protoxide of iron,	47·5	43·775	45·63	1·465
Alumina,	—	0·700	0·70	—
Silica,	—	0·025	0·02	—
Water,	20	25·000	22·5	2·88
	99·5	99·820	100·0	

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* Ann. des Mines, xii. 303.

† Beitrage, iv. 120.

‡ Schweigger's Jahrbuch, i. 77.

This is obviously

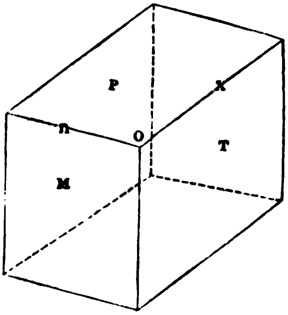
1 atom phosphoric acid,
1$\frac{1}{2}$ atom protoxide of iron,
3 atoms water.

It is therefore a hydrous subsesquiphosphate of iron.

Sp. 7. *Vivianite.*

This mineral occurs in beautiful crystals in Huel Kind, at St. Agnes, in Cornwall, and doubtless in other places; but it is hazardous to specify localities, because two different species have hitherto been confounded under the name of *phosphate of iron.*

Colour various shades of blue and green; at first light, but the colour deepens by exposure, and becomes at last a dirty indigo blue.



Usually crystallized. Primary form a right oblique prism,

M on T 125° 15′

The edge x is often replaced by two planes, making the crystal (which is lengthened by the enlargement of the face T), a twelve-sided prism.

P makes with the planes next it an angle of 125° 56′, while T makes with plane next it an angle of 165° 25′. The edge n is also sometimes replaced by a plane. The solid angle o is also occasionally replaced.

Lustre pearly, almost metallic on the summit of the prism; the other faces have a vitreous lustre.

At first translucent or semitransparent, but by long exposure it becomes opaque.

Sectile; thin laminæ are flexible, but not elastic.

Hardness 1·5 to 2; specific gravity 2·661.

When held in the flame of a spirit lamp it immediately loses its blue colour, and becomes white and opaque. It then exfoliates and melts into a black enamel, which, when the heat is continued, becomes magnetic. When heated in a glass tube it gives out a considerable quantity of pure water.

Its constituents, as determined by Stromeyer,* are as follow:

		Atoms.	
Phosphoric acid,	31·1825	6·93	1
Protoxide of iron,	41·2266	9·16	1·32
Water, .	27·4843	24·43	3·52
	99·8934		

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* *Untersuchungen*, p. 274.

These numbers obviously correspond with

1 atom phosphoric acid,
1⅓ atom protoxide of iron,
3⅓ atoms water.

The analysis of the phosphates is attended with peculiar difficulties, on account of the numerous proportions in which phosphoric acid unites with bases. But if any confidence can be placed in the analyses hitherto made, there are at least four species of phosphated protoxide of iron. These are

1. Diphosphate, composed of
   1 atom phosphoric acid,
   2 atoms protoxide of iron.
2. Mullicite, composed of
   1 atom acid,
   1·66 atom base.
3. Native prussian blue,
   1 atom acid,
   1·5 atom base.
4. Vivianite, composed of
   1 atom acid,
   1⅓ atom base.

A more rigid investigation of the true constitution of these minerals is highly worth the attention of chemists.

Sp. 8. *Diarseniate of Iron.*

White iron sinter.

This mineral is found in the neighbourhood of Freiberg. It was first noticed by Freiesleben, and analyzed by Kersten.

It is a yellowish grey substance, which occurs in kidney-form pieces, soft, approaching to friable, with a coarse earthy fracture, and adhering strongly to the tongue; dull and somewhat rough to the feel.

Its constituents, as determined by Kersten,* are

		Atoms.	
Arsenic acid,	30·25	3·9	1
Peroxide of iron,	40·45	8·09	2·07
Water with trace of sulphuric acid,	28·50	25·11	6·43
	99·20		

These numbers obviously correspond with

1 atom arsenic acid,
2 atoms peroxide of iron,
6 atoms water.

It is therefore a hydrous diarseniate of iron.

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* Schweigger's Jahrbuch, xxiii. 176.

Sp. 9. *Subsesquiarseniate of Iron.*

Cube ore of iron, hexahedral liricone malachite, wurfelerz, pharmacosiderite, ferarseniaté.

This mineral was noticed by Klaproth, but mistaken by him for a ferruginous arseniate of copper. It was first described by Bournon and analyzed by Chenevix.* It occurs in copper veins traversing the older classes of rocks. It has been found in greatest abundance in Cornwall, in several copper mines in the neighbourhood of Redruth. It has been met with also at St. Leonhard in France, and at Schwarzenberg in Saxony.

Colour olive green, passing into yellowish brown and sometimes into yellowish red, also grass-green and emerald green; streak olive green.

Always crystallized. Primary form the cube. The angles or edges, and sometimes both, are replaced by tangent planes. Sometimes the faces of the cube are replaced by two faces meeting in the diagonal of the cubic face, and forming with each other an angle of 176° 30′.

Cleavage difficult and imperfect.

Fracture conchoidal, uneven.

Surface of the cube sometimes streaked parallel to the edges of combinations of the tetrahedron.

Lustre adamantine; not very distinct.

Translucent on the edges; rather sectile. Hardness 2·5. Specific gravity, as determined by Bournon, 3·000.

When exposed to a gentle heat the colour becomes red; in a higher temperature the mineral intumesces, gives out little or no arsenic, and leaves a red powder. Before the blowpipe, on charcoal, it emits copious fumes of arsenic, and melts in the reducing flame into a metallic scoria which acts on the magnetic needle.

Its constituents, according to the analysis of Berzelius,† are:

		Atoms.	
Arsenic acid, .	37·82	4·88	1
Phosphoric acid, .	2·53	0·56	0·11
Peroxide of iron, .	39·20	7·85	1·60
Oxide of copper, .	0·65	0·13	0·02
Water, . . .	18·61	16·54	3·39
Insoluble matter, .	1·76		
	100·57		

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* Phil. Trans. 1801, pp. 190, 220.

† Kong. Vet. Acad. Handl., 1824, p. 354.

If we allow for a very small quantity of phosphate of iron and of copper, it is obvious that the mineral is composed of

1 atom arsenic acid,
1 atom peroxide of iron,
3½ atoms water.

It is therefore a hydrous subsesquiarseniate of iron.

Sp. 10. *Arseniate of Iron.*

This mineral occurs at Antonio Pareira, Villa Rica, in Brazil, and at Loaysa, near Marmato, in Popayan. In the first of these places it occurs in small cavities, in a siliceous perhydrate of iron, which in the neighbourhood of these cavities contains arseniate of iron.

It occurs in small porous masses of a very pale colour; powder white. When triturated with a caustic alkaline ley, it assumes the colour of rust.

It is crystallized, but so irregularly that it has not been possible to determine the form. Berzelius observed prisms terminated by four-sided prisms with square bases.

When heated in a glass tube it gives out water without any evolution of arsenious acid. When heated before the blowpipe it becomes yellow without altering its form.

We have two analyses of this mineral which giveus its constituents as follow:

	*	†
Arsenic acid, . .	50·78	49·6
Peroxide of iron, .	34·85	34·3
Oxide of lead, .	—	0·4
Arseniate of alumina,	0·67	—
Water, . . .	15·55	16·9
	101·85	101·2

These two analyses approach very closely to each other. As both indicate an excess it is probable that at least a part of the oxide of iron is in the state of protoxide. The mean of the two analyses gives us:

		Atoms.
Arsenic acid, .	50·19	6·47
Peroxide of iron, .	34·57	6·91
Water, . .	16·22	14·41

It is obviously composed of

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* Berzelius, Kong. Vet. Acad. Handl., 1824, p. 350.

† Boussingault. Ann. de Chim. et de Phys., xli. 75.

1 atom arsenic acid,
1 atom peroxide of iron,
2 atoms water.

If we admit, with Berzelius, that one-third of the iron is in the state of protoxide, it will follow that the mineral is a compound of

1 atom arseniate of iron,
2 atoms arseniated peroxide of iron,
6 atoms water.

Sp. 11. *Hydrous Disilicate of Iron.*

Sideroschisolite.

This mineral is found at Conghonas do Campo, in Brazil, and was sent to Germany by M. Olfers, during his residence in Brazil. It was described and analyzed by Dr. Wernekink. It occurs in cavities of magnetic pyrites and sparry iron ore in small crystals; usually in crystals.

Colour pure velvet black; powder leek-green.

Crystals very small, almost microscopic. A few occur about half a line in length. They are tetrahedrons, or sometimes hexahedral pyramids. Cleave parallel to the faces of these forms.

Lustre specular splendent.

Opaque.

Hardness 2·5; specific gravity 3.

The crystals fuse very easily before the blowpipe to an iron-black bead attracted by the magnet.

When the fragments are exposed to the flame of a candle they instantly lose their velvet-black colour, become iron-black, and are strongly attracted by the magnet.

The mineral, when in powder, dissolves completely in muriatic acid. The solution is greenish-yellow. When heated in a glass tube pure water is given out to the amount of 7·3 per cent.

The constituents, according to Wernekink's[*] analysis, are:

		Atoms.
Silica, . .	16·3 .	8·15
Protoxide of iron,	75·5 .	16·77
Alumina, .	4·1 .	1·82
Water, . .	7·3 .	6·48
	103·2	

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[*] Poggendorf's Annalen, i. 387.

If we allow the alumina to be accidental, it is obvious that the mineral is a compound of

1 atom silica,
2 atoms protoxide of iron,
¾ atom water.

It is therefore a hydrous disilicate of iron. The small excess of protoxide of iron was probably in combination with the alumina.

Sp. 12. *Chamoisite.*

This mineral occurs in beds of small extent at Chamoisin, in the Valaïs. These beds are thick and numerous and occur in a limestone mountain abounding in ammonites, and probably therefore belonging to the lias formation. It was described and analyzed by Berthier.

Colour dark greenish-grey; powder light greenish-grey.

Fracture unequal; sometimes granular, sometimes earthy.

Magnetic, but less so than magnetic iron ore; opaque.

Hard, but easily scratched by steel.

Specific gravity from 3 to 3·4.

When heated in close vessels it gives out water and becomes black; heated in the open air it becomes ochre-red, and loses less weight than in close vessels, because it absorbs oxygen.

It dissolves in acids with effervescence, owing to a mixture of limestone. There remains a jelly, which is silica coloured by a combustible matter.

Its constituents, by Berthier's[*] analysis, are:

		Atoms.	
Silica,	12	6	1
Protoxide of iron,	50·5	11·22	1·87
Alumina,	6·6	2·9	0·48
Water and bitumen,	14·7	13·06	2·17
Carbonate of lime,	14·4		
Carbonate of magnesia,	1·2		
	99·4		

Probably the alumina and a small portion of the silica are accidental, as well as the carbonates of lime and magnesia. The mineral is obviously a compound of

1 atom silica,
2 atoms protoxide of iron,
2 atoms water.

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[*] Ann. des Mines, v. 393.

It is therefore a bihydrous disilicate of iron, and differs from the last species by containing twice as much water.

Sp. 13. *Anhydrous Silicate of Iron.*

This mineral was discovered in Slavcarrach, one of the Morne mountains, in the North of Ireland, by Mr. Doran. I ascertained its nature by analysis.

Colour dark brown, with something of the metallic lustre.

Texture foliated, and breaks into four-sided prisms, seemingly right, but the summit is very obscure.

Strongly attracted by the magnet, but without polarity; opaque; easily frangible.

Hardness 4; specific gravity 3·8846.

When heated gives out vapour containing ammonia and loses 1·97 per cent. of its weight.

Infusible per se before the blowpipe. In the reducing flame acquires the metallic lustre and the appearance of magnetic ironstone.

Dissolves in muriatic acid leaving silica.

Its constituents (abstracting the moisture) are

		Atoms.
Silica,	29·6	14·8
Protoxide of iron,	68·73	15·27
Protoxide of manganese,	1·78	0·39
	100·11	

It is obviously composed of

1 atom silica,
1 atom protoxide of iron.

Hence if we neglect the manganese as accidental it is an anhydrous silicate of iron.

Sp. 14. *Hydrous Silicate* or *Cronstedtite.*

This mineral was observed about the year 1818 at Przibram, in Bohemia, and was considered at first as a tourmalin. It was described by Zippe, and analyzed by Professor Steinmann in 1821, who gave it the name of Cronstedtite.*

Colour brownish black; streak dark leek green.

Massive, reniform, and crystallized in regular six-sided prisms.

Foliated; cleavage perpendicular to the axis of the prism.

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* *Schweigger's* Jahrbuch, ii. 69.

distinct; the cleavages parallel to the faces of the prism less distinct.

Lustre vitreous; opaque.

Not brittle; thin laminæ elastic.

Hardness 2·5; specific gravity 3·348.

Before the blowpipe it froths a little without melting. With borax it yields a black opaque and hard bead.

When in powder it gelatinizes in concentrated muriatic acid.

Not attracted by the magnet even when in powder.

Its constituents, by Steinmann's analysis, are

			Mean.	Atoms.	
Silica, . .	22·83	22·452	22·614	11·307	1
Protoxide of iron, .	57·61	58·853	58·231	12·94	1·14
Protoxide of manganese,	3·82	2·885	3·352	0·74	0·06
Magnesia, . .	3·25	5·078	4·164	1·66	0·14
Water, . .	10·70	10·700	10·700	9·51	0·84
	98·21	99·968			

These numbers, if we neglect the small quantity of magnesia and manganese present approach pretty nearly to

1 atom silica,
1 atom protoxide of iron,
1 atom water.

The mineral is therefore a hydrous silicate of iron.

Sp. 15. *Hedenbergite.*

Bihydrous bisesquisilicate of iron.

This mineral occurs in an opening called Marmorsgrufvan, near the copper work at Tunaberg, in Södermanland. It is usually accompanied by calcareous spar, thin layers of which are frequently interspersed between the plates of the mineral. It was first described and analyzed by Hedenberg in 1807.* Hence the name Hedenbergite given to it by Berzelius.

Colour greenish black; sometimes dark green, passing into brown; streak olive green; powder olive green inclining to brown.

Massive, but composed of shining plates. These by cleavage yield rhomboids, having nearly the same angles as calcareous spar.

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* Afhandlingar, ii. 164.

Fracture fibrous; opaque.

Hardness 3·5; specific gravity 3·154.

It does not become electric either by heat or friction, but it phosphoresces.

Before the blowpipe it splits, loses its lustre, becomes black, and is attracted by the magnet; does not melt per se. With borax it fuses with effervesence. The bead is at first yellow, it becomes brown, and at last black and opaque. When a little saltpetre is added it acquires a purple colour, indicating the presence of manganese. With biphosphate of soda it fuses into a green bead, which in the oxidizing flame becomes dark red. The colour is destroyed by the reducing flame, but again restored by the oxidizing flame. With carbonate of soda it fuses into a dark green mass, which blackens in a higher temperature.

Its constituents, by Hedenberg's analysis, are

		Atoms.	
Carbonic acid,	1·56	0·56	0·07
Silica,	40·62	20·31	2·59
Protoxide of iron,	35·25	7·83	1
Protoxide of manganese,	0·75	0·16	0·02
Lime,	3·37	0·96	0·12
Alumina,	0·37	0·16	0·02
Water,	16·05	14·26	1·83
	97·97		

The mineral contained a little carbonate of lime. Probably the alumina and manganese were accidental. Omitting these substances as inconsiderable, it is evident that the constitution of Hedenbergite is

$2\frac{1}{2}$ atoms silica,
1 atom protoxide of iron,
2 atoms water.

It is therefore a hydrous bisesquisilicate of iron.

Sect. 16. *Chloropal.*

This mineral was first found near Unghwar, in Hungary, along with the opal. It was sent by Joseph Jonas, keeper of the Hungarian Museum, to Professor Bernhardi of Erfurt. It was described and analyzed in 1822 by Bernhardi and Brandes.* These gentlemen gave it the name of *chloropal*, from its greenish yellow colour, and its association with the opal. Since that time specimens of it have been brought from the island of Ceylon.

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* *Schweigger's* Jahrbuch, v. 29.

Colour greenish yellow and pistachio green.

Massive; composition impalpable, earthy; fracture conchoidal, passing into earthy.

Opaque, or scarcely translucent on the edges; fragile.

Hardness 3·5; specific gravity of a conchoidal specimen 2·000; of the earthy varieties from 1·727 to 1·870. I found that of the Ceylon chloropal 2·105. It has a conchoidal fracture.

It is remarkable for a curious magnetic property. When taken from its original repository it breaks pretty readily into a kind of parallelopiped, the upper end and two adjoining lateral edges of which have the opposite magnetic pole from the lower end and the other two edges.*

Infusible before the blowpipe, but becomes black and quite opaque. With carbonate of soda it melts into a clear glass exhibiting some red points. With borax it fuses into a dark green glass having no red points.

Its constituents are as follow :—

	†	†	‡	Atoms.
Silica, ...	46	45	53	26·5
Protoxide of iron, .	33	32	—	—
Peroxide of iron, .	—	—	26·04	5·21
Magnesia, . .	2	2	1·4	0·56
Alumina, . . .	1	0·75	1·8	0·8
Water, . . .	18	20	18	16
	100	99·75	100·24	

Bernhardi and Brandes found traces of potash and manganese, while I found a trace of lime in the minerals examined.

The two varieties do not agree in their chemical constitution. The Ceylon variety is composed of

5 atoms silica.
1 atom peroxide of iron,
3 atoms water.

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* I could not succeed in verifying this property with the Ceylon variety.

† Bernhardi and Brandes. The first specimen was conchoidal, the second earthy chloropal.

‡ By my analysis. The specimen was a conchoidal chloropal from Ceylon.

while the Hungarian variety is composed of

3 atoms silica,
1 atom protoxide of iron,
2 atoms water.

The first is a quintosilicated peroxide, while the second is a tersilicated protoxide of iron. This last, of course, must be considered as the type of the species. The Ceylon variety obviously constitutes a new species, which would require to be distinguished by a new name.

Sp. 17. *Titaniate of Iron.*

Gregorite; menachanite.

This mineral was first observed mixed with quartz sand in the bed of a rivulet which turned Trigonwell mill, near Menaccan, in the parish of St. Keverne, Cornwall. More recently in a stream near the house of Colonel Sandys, at Lanorth, in the same parish. It has been found also at Botany Bay, in New South Wales, and on the shore of the isle of Siecles, near Brittany, as is obvious from the analysis of the grains by Berthier.*

Colour greyish-black.

Occurs in small angular grains, which are imperfectly lamellar.

Fracture fine grained uneven.

Lustre glistening, between adamantine and metallic.

Opaque; yields to the knife.

Specific gravity 4·427.

The pure grains are not attracted by the magnet, but the ore is mixed with numerous magnetic grains, which are obviously iron sand.

Before the blowpipe it does not decrepitate nor melt; does not fuse with biphosphate of soda, but communicates a green colour, which becomes brown when the salt cools; fuses with borax and produces the same colour.

The constituents, by the analysis of picked grains by Dr. H. Colquhoun, in my laboratory, are as follow:

		Atoms.
Titanic acid,	57·187	10·89
Protoxide of iron,	39·780	8·84
Protoxide of manganese,	2·175	0·48
	99·142	

---

* Ann. des Mines, v. 477.

If we include the oxide of manganese with that of iron, it is obvious that the constitution of the mineral is

1 atom titanic acid,
1 atom protoxide of iron.

The slight excess of the titanic acid is doubtless owing to the difficulty of freeing it completely from iron.

Sp. 18. *Iserine.*

This mineral was first found on the Riesengebirge near the origin of the stream called Iser, disseminated in granite sand, and in alluvial soil along with pyrope in Bohemia. It has been observed also in the sand of the river Don, in Aberdeenshire, in the sand of the Mersey, on the coast of Cheshire opposite Liverpool.

Colour greyish-black, inclining to iron-black.

In very small flattish-angular grains, which have a rough glimmering surface.

Cleavage seemingly conchoidal.

Opaque.

Brittle and easily frangible.

Lustre semimetallic.

Slightly attracted by the magnet.

Specific gravity, by my trials, 4·491. According to Klaproth it varies from 4·5 to 4·650.

Before the blowpipe it melts into a blackish-brown glass, which is slightly attracted by the magnet.

Its constituents, as determined by the analysis of M. H. Rose,* are:

			Atoms.
Titanic acid,	50·12	9·54	1
Protoxide of iron,	49·88	11·08	1·16
	100·00		

It therefore approaches very near to menachanite in its properties, and is probably merely a variety of that species.

Sp. 19. *Subsesquititaniate of Iron.*

This mineral appears to exist in great abundance in Brazil, where, according to M. Montlevade, it constitutes mountains or very thick banks extending a great way, and alternating with transition rocks.

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* Ann. des Mines, xii. 301.

Colour deep grey.

In compact masses, having a great tendency to divide into rhomboidal fragments.

Fracture granular, almost compact, with fine grains a little scaly.

Little or no lustre.

Full of fissures containing a pellicle of reddish-brown mica, also veins of quartz.

Opaque.

Neither its hardness nor specific gravity are noticed.

Attacked by aqua regia, which dissolves the iron.

Its constituents, according to Berthier's analysis,* are:

		Atoms.	
Titanic acid,	41	7·84	1
Peroxide of iron,	56·2	11·24	1·43
Quartz,	2·5	1·25	
Oxide of manganese,	trace		
	99·7		

The constitution is evidently

1 atom titanic acid,
1½ atom peroxide of iron.

It is therefore a subsesquititaniated peroxide of iron.

Sp. 20. *Crightonite.*

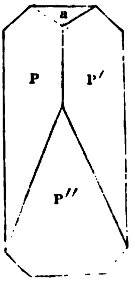
This mineral was discovered by Count Bournon, in 1788; but he made it known to mineralogists only in 1813, in his *Catalogue of his collection.* It was discovered in the cavities of veins in the primary rocks of the Alps in Dauphiné, in the department of the Isere, near the town of Visans. The veins are composed principally of felspar and quartz. They contain also chlorite and anatase.

Colour black.

Always in crystals. They are very small, and have the form of acute rhomboids, having the summits replaced, and being otherwise variously modified by secondary planes.

P on P′	61° 20′
P or P on P″	118° 45′
P or P′ on a	97° 12′
P″ on a	83° 20′

by the measurement of Mr. W. Phillips. The



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* Ann. des Mines, v. 479.

only cleavage observed is parallel to the face a.

Lustre shining and semimetallic.

Brittle and easily frangible.

Has a harsh feel.

Hardness about 4·25; specific gravity not under 3.*

Fracture uneven, passing into conchoidal.

Before the blowpipe it fuses into a greyish-black enamel, having something of the metallic lustre. When this enamel is reduced to powder, it is slightly attracted by the magnet. In borax it dissolves with effervescence into a brownish-green glass. It fuses also with carbonate of soda, and forms a black opaque bead.

It has not been analyzed, but from the behaviour before the blowpipe it contains titanic acid and iron.

Sp. 21. *Nigrin.*

This mineral occurs at Ohlapian, in Transylvania, and was first described and analyzed by Klaproth.† It is said also to have been met with in the Uralian mountains, and in Ceylon.

Colour greyish-black, passing into brownish-red; powder greyish-brown.

It occurs in flat rounded grains about the size of a pea, with here and there slight indications of a crystalline form.

Foliated.

Lustre metallic.

Very hard; brittle.

Specific gravity 4·445.

Before the blowpipe per se experiences very little alteration.

Its constituents, according to the analysis of Klaproth, are:

		Atoms.	
Titanic acid,	84	16	5·14
Protoxide of iron,	14	3·11	1
Protoxide of manganese,	2	0·44	0·14
	100		

These numbers approach very nearly to

5 atoms titanic acid,

1 atom protoxide of iron.

It is therefore a *quintotitaniate of Iron.*

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* Cordier, Ann. des Mines, iii. 451.

† Beitrage ii. 235.

Sp. 22. *Oxalate of Iron.*

Humboldtine. Eisen resin of Breithaupt.

This mineral was discovered by Breithaupt in the Moor coal of Bohemia. He called it *iron resin*, from its appearance, and *mellate of iron* from its supposed composition. It was analyzed by M. Mariano de Rivero, who ascertained it to be oxalate of iron.*

Colour yellow.

Occurs in small flat pieces, consisting of a congeries of crystals, but so irregular that their shape cannot be made out.

Soft enough to be scratched by the nail.

Specific gravity, by my trials, 2·489.

When insulated and rubbed, it acquires negative electricity.

Easily decomposed by heat.

Insoluble in water and alcohol, but easily dissolved by acids. It is decomposed by ammonia, and the ammoniacal solution shoots into crystals of oxalate of ammonia.

According to Mariano de Rivero, it is composed of

		Atoms.
Oxalic acid, . .	46·14 .	10·25
Protoxide of iron, .	53·86 .	11·96
	100·00	

It is much more probable that the salt is a compound of 1 atom of oxalic acid, and 1 atom of protoxide of iron, or of equal weights of each. But it is not quite clear whether Rivero's numbers are derived from analysis, or from calculation founded on erroneous atomic quantities. I have reason to believe that Rivero has been too hasty in his conclusion, that the acid in this mineral is the oxalic. I got a small specimen of it in the summer of 1834, from Dr. Bondie of Dresden, and I requested my nephew, Dr. R. D. Thomson, to examine it. He obtained from 100 of the mineral,

Peroxide of iron, .	53·31
Alumina, . .	6·34
Lime, . . .	0·70
Magnesia, . .	0·60
Silica, . . .	0·50
	61·45

and 40 per cent. of weight was lost by ignition.

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* *Ann. de Chim. et de Phys.* xviii. 207.

On digesting the mineral with carbonate of ammonia and carbonate of soda, an acid in both cases combined with the alkalies. The compound with ammonia gave needles; but the quantity obtained was very small, and the salt obtained did not precipitate lime from the muriate. It was therefore not oxalic acid. The trials I made upon it, led me to infer that it was a new acid, but the quantity of the mineral in my possession was so small, that I was unable to investigate its properties in a satisfactory manner. It would be worth the attention of any chemist who possesses a sufficient quantity of the mineral. He would in all probability discover a new acid.

2. *Double Oxygen Salts.*

These are already pretty numerous, and doubtless more will be discovered as the chemical examination of ferruginous minerals is prosecuted.

Sp. 1. *Hydrous Carbonate of Iron.*

This mineral is not uncommon in lead mines at Alston Moor, where it goes by the name of *brownspar.*

Colour a dirty blackish brown; streak brown.

Consists of a congeries of small irregular rhomboids with curve faces, and entangled in each other.

Lustre pearly, nearly dull.

Opaque; rather brittle.

Hardness 3·25; specific gravity 3·404.

The crystals in the specimen examined were attached to a thin crust of brown matter, having a pearly and splendent lustre, and composed of the same constituents with the crystals, but not altered as they had been by exposure to the weather.

This mineral, by my analysis, was composed of

		Atoms.
Carbonic acid,	18·5	6·72
Protoxide of iron,	30·27	6·72
Peroxide of iron,	37·65	7·53
Protoxide of manganese,	4·75	1·05
Water,	8·30	7·37
	99·47	

The carbonic acid was doubtless united to the protoxide of iron, and the peroxide to the water. The mineral consists very nearly of

8 atoms carbonate of iron.
9 atoms hydrated peroxide of iron.

I think it not unlikely that the mineral at first was a pure carbonate of iron; but that by exposure to the weather, a portion of the iron had been peroxidized, and lost in consequence its carbonic acid, which was replaced by an equivalent quantity of water.

Sp. 2. *Magnesia-Carbonate of Iron.*

Many specimens of what is usually called *sparry iron* ore, or carbonate of iron, contain also definite quantities of carbonate of magnesia.

This is the case with the sparry iron ore of Grande Fosse, near Vizille.

Colour light yellow.

Texture foliated and divisible into large rhomboids. Its constituents, determined by Berthier,* are

		Atoms.
Protoxide of iron, .	43·6 .	9·68
Protoxide of manganese,	1·0 .	0·22
Magnesia, . .	12·8 .	5·12
Carbonic acid, .	42·6 .	15·49
	100·0	

These numbers approach pretty nearly to
2 atoms carbonate of iron,
1 atom carbonate of magnesia.

The same carbonates united in various other proportions, may be seen in Berthier's analyses of sparry iron ore.† It is not unlikely, therefore, that such minerals are better entitled to rank as mixtures than peculiar species. This is the reason why I only notice them here.‡

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* Ann. des Mines (2d series), iii. 30.

† Ibid.

‡ Doubtless the *breunnerite* of Mohs, which from the analysis of Stromeyer, appears to consist of
11 atoms carbonate of magnesia,
1 atom carbonate of iron and manganese,
is also a mixture, and stands nearly at the opposite extremity of the scale from the salt noticed in the text. It has a yellowish brown colour. Crystal rhomboids of 107° 22′. Specific gravity 3·1; hardness 4·25; lustre vitreous. Found in Rothen Kopf in the Zillerthal, Tyrol, imbedded in chloride slate.

Sp. 3. *Manganeso-Diphosphate of Iron.*

Pitchy iron ore. Ferruginous phosphate of iron.

This mineral was discovered by Alluau, near Limoges in France, in a vein of quartz traversing granite.

Colour blackish brown; streak yellowish grey.

Massive; cleavage in three directions perpendicular to each other. Hence the primary form must be a cube, or a right rectangular prism.

Fracture small conchoidal.

Translucent on the edges, or opaque.

Lustre resinous, inclining to adamantine; brittle.

Hardness 5 to 5·5; specific gravity, as determined by Breithaupt, 3·562. Vauquelin found it 3·439.

Before the blowpipe it melts easily into a black scoria.

Dissolves readily in nitric acid without effervescence.

Its constituents, by Berzelius's analysis,* are

		Atoms.
Phosphoric acid,	32·8	7·28
Protoxide of iron,	31·9	7·08
Protoxide of manganese,	32·6	7·24
Phosphate of lime,	3·2	
	100·5	

Leaving out the phosphate of lime as accidental, the constituents are

1 atom phosphoric acid,
1 atom protoxide of iron,
1 atom protoxide of manganese.

Hence the constitution of the mineral must be

1 atom diphosphate of iron,
1 atom diphosphate of manganese.

Sp. 4. *Alumina-Sulphate of Iron.*

This salt occurred some years ago abundantly in the shale of the wrought out coal beds, at Hurlet and Campsie, near Glasgow.

Colour snow-white.

In fine needles about an inch long, having some breadth, but no sensible thickness.

Taste sweet and astringent. Soluble in water. When heated loses water and becomes red. The constituents are as follows:

---

* Ann. des Mines, v. 234.

	*	†	‡	‡
Sulphuric acid, . .	34·4	30·9	35·600	28·635
Protoxide of iron, .	12·0	20·7	13·560	19·935
Alumina, . . .	8·8	5·2	7·127	2·850
Magnesia, . .	0·8	—	—	—
Water, . . .	44·0	43·2	43·713	48·580
	100·0	100	100	100

The difference between these results shows clearly, that the mineral varies a little in its composition.

The analyses of my nephew, which were made with great care, but the last of the two upon the purest specimen, give

1st.		2d.
$2\frac{1}{3}$ atoms sulphuric acid,	and	5·72 atoms acid,
1 atom protoxide of iron,		4·43 atoms protoxide of iron,
1 atom alumina,	.	1·26 atoms alumina,
13 atoms water,	.	43·18 atoms water.

The second of these analyses, which was on the purest specimen, gives us

$3\frac{1}{2}$ atoms sulphate of iron,
1 atom sulphate of alumina,
34 atoms water.

The water is equivalent to $7\frac{1}{2}$ atoms, for each atom of salt in the compound, which exceed the water of crystallization of these salts when separate.

Sp. 5. *Hetopizite.*

This mineral occurs at Hureaux, in the commune of St. Sylvestre, Haute Vienne. It was first noticed by M. Alluau, who sent a specimen of it to Vauquelin for analysis. It has been described and analyzed by M. Dufresnoy.§

Colour greyish-green, with a shade of blue; but by exposure to the air it becomes violet, and acquires a semimetallic lustre.

Primary form of the crystal, derived from cleavage, a rhomboidal prism, with angles of about 100° and 80°. Occurs usually in foliated masses, which have a three-fold cleavage.

Scratches glass, but not quartz; lustre vitreous.

Specific gravity 3·524; after it has been altered by exposure it is reduced to 3·390. Soluble in acids.

* Berthier, Ann. des Mines, v. 259.

† Phillips, Annals of Philosophy (2d series), v. 446.

‡ *Analyzed in my laboratory* by Dr. R. D. Thomson.

§ *Ann. de Chim. et de Phys.*, xli. 342.

Before the blowpipe fuses into a brown enamel, with a semimetallic lustre.

Its constituents, by the analysis of Dufresnoy, are

		Atoms.
Phosphoric acid, .	41·777 .	9·28
Protoxide of iron, .	35·000 .	7·77
Protoxide of manganese,	16·180 .	3·58
Moisture, . .	4·40 .	3·9
Silica, . .	2·2 .	1·1
	99·557	

The constituents are obviously

2 atoms phosphate of iron,
1 atom diphosphate of manganese,
1 atom water.

The formula is $2f\dot{P}h+mn^2 Ph+Aq$.

Sp. 6. *Carbono-phosphate of Iron.*

This mineral occurs in beds in the Jura limestone at Vignes, west from Hayange, and is employed by the iron smelters on the Moselle. It was described and analyzed in 1827, by M. Karsten.*

Colour deep greenish-blue, and not unlike chamoisite in appearance, though quite different from that mineral in its constitution. Powder deep greenish-blue.

Texture oolitic. The grains not larger than a millet seed.

Magnetic. Specific gravity 3·71.

Dissolves slowly and with effervescence in muriatic acid; an insoluble residue of silica remains, which does not gelatinize, and therefore could not have been in combination with the iron, but only accidentally present.

The constituents, by Karsten's analysis, are

		Atoms.	
Peroxide of iron,	41·120 .	8·22 .	10·96
Protoxide of iron,	29·980 .	6·66 .	8·86
Carbonic acid, .	11·873 .	4·31 .	5·74
Phosphoric acid, .	3·380 .	0·75 .	1
Lime, . .	2·140		
Magnesia, .	0·775		
Water, . .	2·900		
Silica, . .	6·990		
	99·158		

---

* Ann. des Mines (second series), iii. 253.

It is pretty obvious that all the constituents, except the four first, are impurities. The carbonic acid must have been in combination with protoxide of iron. The phosphoric acid was probably in combination with peroxide of iron, in the state of diphosphate. If these suppositions be admitted, we have

5·74 atoms carbonate of iron,
1 atom diphosphate
3·14 atoms protoxide of iron,
8·88 atoms peroxide of iron,

This approaches
6 atoms carbonate of iron,
1 atom diphosphate of iron,

$$\text{3 atoms of a compound of} \left\{ \begin{array}{l} \text{1 atom protoxide} \\ \text{3 atoms peroxide} \end{array} \right\} \text{of iron.}$$

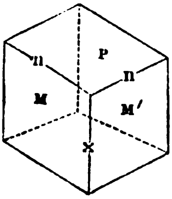
But in all probability the ore is rather a mechanical mixture, than a chemical compound.

Sp. 7. *Scorodite.*

Martial arseniate of copper—diarsenite of iron.

This mineral was first observed in Tincroft mine, Cornwall, and from Chenevix's analysis was considered as an arseniate of copper, combined with oxide of iron.* It was afterwards found in the primary mountains at Schwartzenberg, in Saxony, and was described by Breithaupt under the name of scorodite.†

Colour leek-green, which passes into white, into olive-green, and into liver-brown. The Cornish variety is pale sky-blue; streak white.



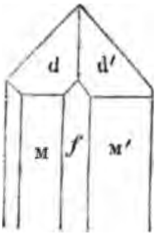
In crystals. Primary form a right rhombic prism,

M on M′ 120°

But most commonly it is modified as in the margin, by the edges n, n, x being replaced by the planes d, d′, f.

M on d or M′ on d′ 141° 26′
d on d′ 103°
M or M′ on *f* 149° 55′

So that *f* is a tangent plane.



Fracture uneven.

Lustre vitreous, inclining to adamantine on the surface, and to resinous in the interior.

Translucent on the edges, to semitransparent; rather brittle.

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* *Phil. Trans., 1801, pp. 191, 218.*

† From σκοροδον, garlick.

Hardness 3·5 to 4; specific gravity, according to Bournon, 3·4; according to Haidinger it varies from 3·162 to 3·3.

Before the blowpipe it emits an arsenical odour, and melts into a reddish-brown scoria, which acts on the magnet, if the arsenic has been driven off.

According to the analysis of Ficinus, its constituents are

		Atoms.
Arsenious acid,	31·4	6·61
Sulphuric acid,	1·54	0·31
Protoxide of iron,	36·25	8·05
Protoxide of manganese,	4·00	0·89
Lime,	2	0·57
Magnesia,	2	0·8
Water,	18	16·0
Gangue,	1·4	
	96·59	

In another analysis the amount of the oxides of iron and manganese, with the lime and magnesia, was 47·8 per cent., but he did not determine the proportions of each.*

If we pay no attention to the quantity wanting to complete the weight employed in the analysis, it is obvious that scorodite is a subsesquiarsenite of iron, with a little subsesquiarsenite of manganese, lime, and magnesia, and a very little sulphate of lime. The constituents are

4 atoms subsesquiarsenite of iron,

1 atom subsesquiarsenite of manganese, lime, and magnesia, with a trace of sulphate of lime.

Sp. 8. *Cacoxenite.*†

Childrenite.

This mineral was found in an iron mine at Hrbetk, in Bohemia. The iron ore is clay ironstone, which occurs in the coal formation. The cacoxenite occurs in tufts upon the surface of the stone in small veins, and bears a striking resemblance to karpholite.

Colour dull yellow; lustre silky; streak yellowish-red.

Composed of small crystals in tufts. Its specific gravity, as determined by Mr. Richardson, is 2·336; soft; sectile.

Heated alone in a glass tube gives off water, but no fluoric acid, and the colour changes to a dark red brown. Before the blowpipe alone on charcoal suffers no change except the colour becoming dark red brown. On platinum wire, with carbonate of soda, does not fuse. With borax fuses readily into a dark red-coloured bead, quite transparent in the oxidizing flame, which changes to yellow in the reducing flame; with salt of phosphorous, in the oxidizing flame, fuses into a yellow transparent bead, which does not change in the reducing flame.

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* Schweigger's Jahrbuch, iv. 198.

† From κακος, bad, and ξενος, a *guest*; because its presence is injurious to iron ore.

Its constituents, according to the analysis of Professor Steinmann, of Prague, are

		Atoms.	
Silica,	8·90	4·42	1·11
Phosphoric acid,	17·86	3·96	1
Alumina,	10·01	4·44	1·11
Peroxide of iron,	36·32	7·26	1·83
Lime,	0·15	—	—
Water & fluoric acid,	25·95	23	5·8
	99·19		

But Mr. Richardson made a very careful analysis of it in my laboratory, and obtained

		Atoms.
Phosphoric acid,	20·5	1
Peroxide of iron,	43·1	1·89
Lime,	1·1	0·07
Magnesia,	0·9	0·08
Silica,	2·1	0·25
Oxide of manganese,	trace	—
Water,	30·2	5·99
	97·9	

It is therefore a diphosphated peroxide of iron, contining 6 atoms of water. The silica, alumina, &c., found by Steinmann, must have been impurities.

Sp. 9. *Sulpharseniate of Iron.*

Eisensinter, pittizite, pitchy iron ore.

This mineral was first described by Karsten, and analyzed by Klaproth. Stromeyer thinks that it is derived from the decomposition of mispickel; because in those parts of Saxony where it occurs, mispickel is abundant. It was first found in a mine near Freyberg; more lately in the district of Pless, in Upper Silesia, and in Britanny.

Colour blackish-brown, or greyish-black; streak lemon yellow. Massive, or incrusting other minerals;[*] fracture flat conchoidal, or fine grained; lustre resinous, shining, or glistening; translucent, at least on the edges; easily scratched by the knife; brittle; specific gravity, as determined by Karsten, 2·40.

Its constituents, according to the analysis of Stromeyer,[†] are

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[*] Count Bournon, in his *Catalogue*, describes a pitchy iron ore as *occurring in rectangular* prisms, either perfect or with two opposite angles *replaced so as to convert the* prism into an octahedron.

[†] *Untersuchungen, p. 244.*

		Atoms.	
Arsenic acid, .	26·0591	. 3·59	. 1·73
Sulphuric acid, .	10·0381	. 2·07	. 1
Peroxide of iron, .	33·0960	. 6·62	. 3·19
Sesquioxide of manganese,	0·6417	. 0·13	
Water, . .	29·2556	. 26	. 12·5
	99·0105		

These numbers correspond with
$1\frac{3}{4}$ atom arseniated peroxide of iron,
1 atom subsesquisulphated peroxide of iron,
$12\frac{1}{2}$ atoms water.

Sp. 10. *Thraulite.*

Hisingerite, hydrous sesquisilicate of iron.

This mineral occurs at Riddarhyttan, in Westmanland, and at Bodenmais, in Germany. It was first described and analyzed by Hisinger.[*] The variety from Bodenmais was afterwards analyzed by Professor Kobell[†] of München, who distinguished it by the name of *thraulite*.[‡]

Colour black; powder brownish yellow.

Occurs in roundish nodules an inch or more in diameter. No regular form has been observed.

Fracture uneven, or imperfect conchoidal. Splendent; opaque. Brittle; not particularly heavy.

When heated in a glass tube it gives out water; before the blowpipe it shows some symptoms of fusion, the edges being rounded; but the lustre and appearance of the fragment is not altered; after ignition it is strongly attracted by the magnet.

The constituents, according to the analyses of Hisinger and Kobell, are as follow:—

	§	§	‖	Atoms.	
Silica, . .	36·30	31·775	31·28	15·64	1·53
Peroxide of iron,	44·39	49·869	50·86	10·17	1
Water, . .	20·70	—	19·12	17	1·67
	101·39		101·26		

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[*] Poggendorf's Annalen, xiii. 505.

[†] Ibid. xiv. 467.

[‡] From θραυλος, easily frangible.

[§] Hisinger. The first specimen was from Ridderhyttan, the second from Bodenmais. Want of a sufficient quantity of the mineral prevented him from determining the water.

[‖] Kobell. The specimen was from Bodenmais.

If we take the analysis of Kobell as our standard, it is obvious that the constitution of the mineral is

1½ atom silica,
1 atom peroxide of iron,
1⅔ atom water.

Hisinger is of opinion, that the oxide of iron is composed of 2 atoms peroxide, and 1 atom protoxide. If that supposition be correct, thraulite consists of

1 atom sesquisilicate of iron,
2 atoms sesquisilicated peroxide of iron,
5 atoms water.

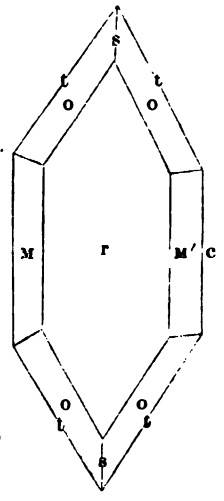
The specimens analyzed were not free from an admixture of magnetic pyrites.

Sp. 11. *Achmite.**

This mineral occurs at Eger, in South Norway, in a quartz ball, in a kind of granite, which Haussmann and Von Buch considered as belonging to the transition class of rocks. It was described by Stromeyer, and analyzed by Berzelius in 1821.†

Colour brownish or reddish brown; in the fracture blackish green.

It occurs in crystals, the primary form of which seems to be a right oblique prism M on M′ 86° 56′. But it usually occurs in the form represented in the margin; a six-sided prism terminated by a four-sided pyramid.



The measurements of this crystal by Mitcherlich are as follow:—

M on M′ 86° 56′
M on r 133° 28′
M on e 136° 32′
s on s 35°
s on r 162° 30′
t on t 28° 19′
t on e 165° 15′·5
Edge t 104° 26′
Edge s 80°
o on r 140°

Four cleavages may be observed, two parallel to the faces M, M, and two seemingly to the diagonals of the base.

Fracture from uneven to earthy.

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* From ἀκμη, *the point of a sword.* Named from the pointed form of the crystals.

† *Kong. Vet. Acad. Handl.*, 1821, p. 160.

Lustre vitreous.

Translucent when in very thin pieces.

Scratches glass; hardness 4; specific gravity, by my trials, 3·398.

Before the blowpipe fuses into a black bead.

Its constituents, by the analyses of Berzelius and Captain Lehunt, are as follows:—

	*		†		Atoms.
Silica, .	55·25	.	52·016	.	26·01
Protoxide of iron,	31·25	.	28·080	.	6·24
Soda, .	10·40	.	13·333	.	3·44
Protoxide of mangan.,	1·08	.	3·487	.	0·77
Lime, .	0·72	.	0·876	.	0·25
Magnesia, .	—	.	0·504	.	0·2
Alumina, .	—	.	0·685	.	0·3
	98·70		98·981		

I am disposed to consider the specimen analyzed by Captain Lehunt as the purest. The analysis was conducted with great care. If we calculate from it, we have

4 atoms bisilicate of iron,

2 atoms tersilicate of soda,

1 atom bisilicates of manganese, lime, magnesia, and alumina.

The formula is $4fS^2+2NS^3+(\frac{1}{6}Al+\frac{1}{6}Mg+\frac{1}{6}Cal+\frac{3}{6}mn)S^2$. Or, if we omit the bisilicates of manganese, lime, magnesia, and alumina, as accidental impurities, achmite will be a compound of

2 atoms bisilicate of iron,
1 atom tersilicate of soda.

Its formula will be $2fS^2+NS^3$.

Sp. 12. *Krokidolite.*

This mineral was found at Orange River, near the Cape of Good Hope, in Southern Africa. The first specimens of it were brought to Europe by Lichtenstein. These were described and analyzed by Klaproth under the name of blue ironstone from the Cape of Good Hope.‡ Specimens of another variety of this mineral from the same place were described and analyzed by Haussmann and Stromeyer in 1830.[*] Haussmann gave the mineral the name of *krokidolite*,[†] because he considered the name imposed by Klaproth as not sufficiently free from ambiguity. The variety examined by Klaproth was *compact*, that examined by Haussmann and Stromeyer *asbestiform*.

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* Berzelius. Ibid. The iron was in the state of peroxide.

† Captain Lehunt. The analysis was twice repeated in my laboratory, and the specimen was exceedingly pure.

‡ Beitrage, vi. 257.

Colour lavender blue; powder the same.

The compact variety is massive; the asbestiform is composed of fibres or strings about 1·8 inch long, and inclined to each other at angles of 106° and 74°. This fibrous matter constitutes a slaty mass about half a line thick. Between each slate a thin layer of magnetic ironstone is interposed.

Opaque; the fibres possess considerable elasticity.

Hardness 4; specific gravity of both varieties 3·200.

When heated to redness it melts easily into a black, shining, opaque, somewhat frothy glass, which is attracted by the magnet. When single fibres are held in the flame of a spirit lamp they readily melt. This enables us to distinguish this mineral with ease from asbestus.

When heated to fusion in hydrogen gas it forms an iron grey glass full of vesicles, strongly attracted by the magnet, and dissolving in muriatic acid with the evolution of hydrogen gas.

With borax it fuses very readily into a green-coloured transparent bead, which the addition of a little saltpetre renders reddish brown.

The constituents of this mineral are

	‡	§	§	Atoms.
Silica, . . .	50	50·81	51·64	25·6
Protoxide of iron, .	40·5	33·88	34·38	7·57
Protoxide of mangan.,	—	0·17	0·02	—
Magnesia, . .	—	2·32	2·64	—
Lime, . . .	1·5	0·02	0·05	—
Soda, . . .	5	7·03	7·11	1·77
Water, . . .	3	5·58	4·01	4·28
	100	99·81	99·85	

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[*] Poggendorf's Annalen, xxiii. 153.

[†] From κροκις, *woof*, from the texture of the asbestous variety.

[‡] Klaproth, Beitrage, vi. 156. The specimen examined was the compact variety.

[§] Stromeyer, Poggendorf's Annalen, xxiii. 156. Both specimens *belonged to the* asbestiform variety.

If we adopt the analysis of Stromeyer, because the specimens which he examined were probably the purest, the constitution of krokidolite will be

4 atoms tersilicate of iron,
1 atom sesquisilicate of soda,
2½ atoms water.

Sp. 13. *Chromiron ore.*

Chromate of iron.

This mineral was first observed in the department of the Var in France, near Gassin, in nodules in serpentine. It occurs in the same rock near Nantes, in Styria, in the Uralian mountains, in the islands of Unst and Fellar, two of the Shetlands; at Portsoy, in Banffshire, in the Bare hills, near Baltimore, and in various other parts of the United States.

Colour between iron black and brownish black; streak brown.

Massive and crystallized in regular octahedrons.

Lustre imperfect metallic.

Fracture uneven, imperfect conchoidal.

Opaque; brittle.

Hardness 5·5; specific gravity of the pure crystals 4·321.

Not attracted by the magnet, if pure.

This mineral was analyzed by Vauquelin, Laugier, Klaproth, Seybert, and Berthier;* but none of these chemists having employed pure specimens, their results do not agree with each other. I picked out pure octahedrons from specimens from the Bare hills, and obtained by analyzing them, the following constituents:—

Green oxide of chromium,	52·95	10·6
Peroxide of iron,	29·24	5·85
Alumina,	12·22	5·43
White matter,	3·09	
Water,	0·70	
Silica, trace,		
	98·20	

These numbers correspond with

2 atoms green oxide of chromium,
1 atom peroxide of iron,
1 atom alumina.

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* See Phil. Trans., 1827, p. 226.

If the green oxide of chromium be considered as acting the part of an acid, we may consider the ore as composed of

1 atom chromite of iron,
1 atom chromite of alumina.[*]

Sp. 14. *Arfvedsonite.*

This mineral was brought from Kargardluarduk, in Greenland, by Sir Charles Giesecké. It was known by the name of *ferruginous hornblende*, till Mr. Brooke found that the form of its crystals did not agree with that of hornblende. This led him to distinguish it by the name of *Arfvedsonite.*

Colour pure black. On some parts of the edge it has a slight tinge of blue, but none of green.

The specimens which I have seen are in large oblique four-sided prisms without terminations. The angles of the prism, by the measurement of Brooke, are 123° 55′ and 56° 5′; while those of amphibole are 124° 30′ and 55° 30′.

The prism splits easily parallel to its longitudinal faces, and may be obtained in pretty thin plates, but no cleavage can be observed parallel to the base. We are therefore ignorant whether the prism be right or oblique.

Lustre resinous.

Opaque.

Hardness 4·5; specific gravity 3·369. Its constituents, by my analysis, are

		Atoms.
Silica, .	50·508 .	25·25
Peroxide of iron,	35·144 .	7·03
Sesquiox. of mangan.,	8·920 .	1·78
Alumina, .	2·488 .	1·10
Lime, .	1·560 .	0·44
Moisture, .	0·960	
	99·580	

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[*] Berthier is of opinion that the silica found in this ore by Vauquelin, by himself, and by some other analists, is essential to the mineral, and endeavours to prove his opinion by the phenomena of the analysis. *Traité des Essais par la voie seche*, ii. 262. I picked out a quantity of octahedrons from the Baltimore ore, in which silica had been found abundantly, and on analyzing them obtained the same constituents as given in the text, with merely a trace of silica. Indeed it would be difficult to conceive the chemical nature of chromium ore, such as it is exhibited by the analyses hitherto made. Earthy matter may be detected by the eye in most specimens of *chrome iron ore,* and how it could be separated unless pure crystals *be picked out, I do not* understand.

Omitting the alumina and lime as accidental impurities, the mineral is obviously a compound of

4 atoms tersilicate of iron,
1 atom tersilicate of manganese.

The formula is $4fS^3+mnS^3$.

Sp. 15. *Knebelite.*

This name was given by Dobereiner to a mineral, a specimen of which he got from Major Von Knebel, but the locality of which is unknown.

Colour grey; spotted dirty white, red, brown, and green.

Massive; external surface uneven and full of holes.

Fracture imperfect conchoidal.

Lustre glistening.

Opaque; hard; brittle.

Specific gravity 3·714.

Infusible per se before the blowpipe, but with borax it melts into a dark olive-green bead.

Its constituents, as determined by Dobereiner, are

		Atoms.
Silica,	32·5	16·25
Protoxide of iron,	32	7·11
Protoxide of manganese,	35	7·77
	99·5	

These numbers approach pretty near

1 atom silicate of iron,
1 atom silicate of manganese.

Sp. 16. *Columbite.*

Tantalite.

The first specimen of this mineral noticed by chemists, is one still in the British Museum, which was analyzed by Mr. Hatchett, and found to contain a new metal, to which he gave the name of *Columbium.* This specimen had been sent to Sir Hans Sloane by Governor Winthrop. The locality was unknown; but Dr. Torrey has detected the mineral in a remarkable rock at Haddam, in New England, and rendered it probable that it was from this place that Mr. Winthrop's specimen had been procured.* The same mineral occurs at Kimito, in Finland; but its nature remained unknown till its analysis by Ekeberg detected in it the same metal which had been previously discovered by Hatchett, and which he called *tantalum*. It has been found also at Bodenmais, in Bavaria.

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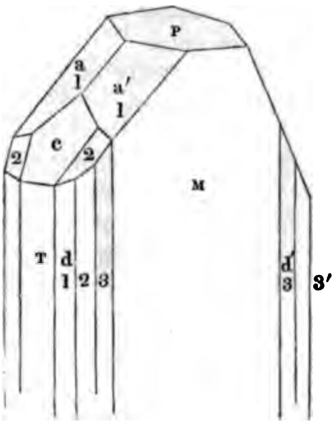
* Annals of Philosophy (second series), viii. 359.

Colour iron black, sometimes with a tinge of blue; streak dark brownish black.

It occurs in single crystals and in small crystalline masses. The crystals are mostly incomplete, but present the general form of flat quadrangular prisms striated longitudinally. The primary form appears to be a right rectangular prism. The figure in the margin represents all the secondary faces hitherto observed.



P on T 90°
T on M 90°
P on a_1 or $\acute{a}_1$ 136° 30′
P on c 120°
T on d_1 156° 30′
T on d_2 114° 30′
T on c 150°

According to the measurement of Mr. W. Phillips.

Fracture imperfect, conchoidal, or uneven.

Lustre imperfect metallic.

Opaque.

Hardness 5·25; specific gravity, as determined by Ekeberg, 7·963. Berzelius found the specific gravity to vary from 7·236 to 7·655.* The specimen analyzed by Nordenskiöld 7·264.

On charcoal it suffers no change before the blowpipe. It is slowly but perfectly fusible with borax.

The constituents of the Finland columbite, according to Berzelius' analysis,† are

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* Afhandlingar, iv. 263 and vi. 238.

† Ibid. iv. 264. Nordenskiöld analyzed another specimen from Tamela. Its constituents were

Columbic acid, .	83·44
Protoxide of iron, .	13·75
Protoxide of manganese,	1·12
Oxide of tin, .	trace
	98·31

We see from this, that the iron may be substituted for the manganese in this *mineral*. (*See Berzelius*, Jahresbericht, 1833, p. 190.)

		Atoms.
Columbic acid,	83·2	3·27
Protoxide of iron,	7·2	1·6
Protoxide of manganese,	7·4	1·64
Oxide of tin,	0·6	
	98·4	

These numbers obviously correspond with

1 atom columbate of iron,
1 atom columbate of manganese.

The columbite from Brodbo, also analyzed by Berzelius, was not so pure.

The constituents of Kimito columbite, determined by the same chemist, are

		Atoms.
Columbic acid,	85·85	3·37
Peroxide of iron,	14·41	2·88
Sesquioxide of mangan.,	1·79	0·36
Oxide of tin,	0·80	
Lime,	0·56	
Silica,	0·72	
	104·13	

Doubtless the iron and manganese in the mineral were in the state of protoxides.

The only difference between this variety and the preceding is, that most of the oxide of manganese is wanting in it. Instead of being a compound of 1 atom columbate of iron, and 1 atom columbate of manganese, this variety is composed of

8 atoms columbate of iron,
1 atom columbate of manganese.

Sp. 17. *Wolfram.*

Scheelate of iron and manganese. Tungstate of iron and manganese.

This ore is a frequent companion of tinstone in veins and beds. It is said also to occur in lead veins traversing greywacke. It is found in almost all the Saxon and Bohemian tin mines, and in many parts of Cornwall. In the Principality of Anhalt, it occurs in veins in greywacke. In the island of Rona it was discovered in a vein of graphic granite in gneiss. It is found likewise in Siberia, and in the United States of America.

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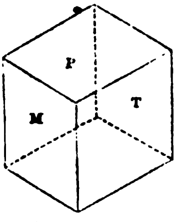
* Afhandlingar, vi. 237.

Colour greyish and brownish black; streak dark brownish black.

It occurs massive and in crystals. The primary form is a right oblique angled prism.



M on T 117° 22′

According to the measurement of Mr. W. Phillips. The edges of the prism are most frequently replaced by faces, which sometimes are so large as nearly to conceal the primary faces of the prism, or at least to reduce them to a very small size.

Texture foliated; fracture uneven.

Lustre imperfect metallic; opaque; not very brittle.

Hardness 5; specific gravity 7·155.

Before the blowpipe decrepitates, but in a sufficiently elevated temperature, may be melted into a globule, whose surface is covered with crystals having the metallic lustre. With borax fuses into a green globule. With biphosphate of soda it melts into a transparent bead having a deep red colour.

Its constituents, according to the best analyses hitherto made, are

	*	†	‡
Tungstic acid,	74·666	73·511	73·60
Protoxide of iron,	17·594	20·745	11·20
Protoxide of manganese,	5·640	5·744	15·75
Silica,	2·100	—	—
	100	100	100·55

The result of Berzelius' analysis gives the following atomic numbers:

Tungstic acid,	4·81
Protoxide of iron,	3·9
Protoxide of manganese,	1·25

These approach pretty nearly

3 atoms tungstate of iron,
1 atom tungstate of manganese.

The specimen analyzed by Mr. Richardson, was a compound of 3 atoms tungstate of iron, and 4 atoms tungstate of manganese.

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* Berzelius, Afhandlingar, iv. 304.

† Vauquelin, Annals of Philosophy (2d series), xi. 330.

‡ Analyzed by Mr. Richardson in my laboratory. The specimen was from Bohemia. *Its specific* gravity was 7·001.

Sp. 18. *Ilmenite.*

This name has been given to a variety of titaniferous iron ore, brought from Ilmen sea near Minsk, by M. Menge, and deposited in the Royal Mineralogical Museum at Berlin. It was first described by M. G. Rose,* and analyzed by Mosander.†

Colour brownish black; streak black.

Crystallized, and the form of the crystals is the same as that of anhydrous peroxide of iron.

Lustre metallic, shining.

Translucent; brittle.

Slightly magnetic.

Hardness 5·75; specific gravity from 4·766 to 4·808.

Behaviour before the blowpipe similar to that of titaniferous iron ore. When fused with biphosphate of soda in the oxidizing flame, the colour is green as long as it is hot; but on cooling it becomes reddish brown. In the reducing flame it is reddish while hot, but on cooling becomes greenish, and at last almost colourless.

Its constituents, as determined by the analysis of Mosander, are as follows:

			Mean.	Atoms.
Titanic acid,	46·92	46·67	46·79	8·94
Peroxide of iron,	10·74	11·71	11·22	2·24
Protoxide of iron,	37·86	35·37	36·61	8·13
Protoxide of manganese,	2·73	2·39	2·56	1·00
Magnesia,	1·14	0·60	0·87	
Lime,	—	0·25		
Protoxide of chromium,	—	0·38		
Silica,	—	2·80		
	99·39	100·17		

These numbers approach pretty nearly to
4 atoms titaniate of iron,
1 atom dititaniated peroxide of iron.

Sp. 19. *Titaniferous Iron Ore.*

This mineral seems to have been first observed at Arendal in Norway. It occurs also at Egersund, in the valley of Gastein in Salzburg, in Bohemia, at Maisdon in the department of Loire Inferîeure, in Brazil, in the United States, and doubtless in many other localities. Its characters are not always the same, and the probability is, that more than one species are at present confounded under the name of *titaniferous iron ore.*

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* Poggendorf's Annalen, ix. 286.

† Kong. Vet. Acad. Handl., 1829, p. 220.

Colour iron grey, but frequently more inclining to white; streak black.

Massive and crystallized. The primary form, according to Mohs, is a rhomboid of 85° 59′.

Texture foliated; fracture conchoidal.

Opaque; brittle.

Lustre imperfect metallic, to perfect metallic.

Hardness 5 to 5·5; specific gravity from 4·488 to 4·787.[*] Berthier found the specific gravity of the titaniferous iron from Maisdon, which is very impure, only 3·65.[†]

Sometimes attracted by the magnet, and sometimes not. The one from Brazil is even possessed of poles.

Before the blowpipe the thin edges are rounded, but it does not fuse. With reagents it behaves as the minerals composed of titanic acid and oxide of iron, already described.

The following table exhibits the constituents of this mineral, according to the best analyses hitherto made:

	‡	‡	‡	§	§	§	‖	¶
Titanic acid, .	24·19	23·59	20·41	39·04	42·57	41·08	41·0	9·0
Peroxide of iron,	53·01	58·51	55·23	29·16	23·21	25·93	56·2	44·0
Protoxide of iron,	19·91	13·90	19·48	27·23	29·27	29·04	—	—
Protoxide of mangan.,	—	—	—	0·21	—	—	trace	—
Alumina, . .	—	—	—	—	—	—	—	3·0
Magnesia, . .	0·68	1·10	0·73	2·30	1·22	1·94	—	10·0
Lime, . .	0·33	0·86	0·32	0·96	0·50	0·49	—	—
Oxide of chromium,	—	0·44	—	0·12	0·33	—	—	—
Oxide of tin, .	—	—	3·64	—	—	—	—	—
Oxide of cerium,	—	—	—	—	—	0·58	—	—
Silica, . .	1·17	1·88	0·80	0·81	1·65	0·07	2·5	34·0
	99·29	100·28	100·61	99·33	98·75	99·18	99·7	100

It is obvious at a glance, that the titaniferous iron from Arendal, differs essentially in its composition from that of

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[*] Mosander, Kong. Vet. Acad. Hand., 1829, p. 226.

[†] Memoires de Berthier, i. 158.

[‡] Mosander, Kong. Vet. Acad. Hand., 1829, p. 227. The specimens were from Arendal, and in crystals. The second specimen was not attracted by the magnet, the third was attracted, and the first was a mixture of the two.

[§] Mosander, ibid. p. 228. The specimens were from Egersund, and amorphous.

[‖] Berthier, Ann. des Mines, v. 479. The specimen was from Brazil.

[¶] Berthier, Memoires, i. 158. The specimen was from Maisdon.

Egersund; while this last agrees pretty nearly with that from Brazil.

The mean of the first three analyses (neglecting every constituent except the titanic acid and oxides of iron) gives us

		Atoms.
Titanic acid,	22·73	4·13
Peroxide of iron,	55·58	11·12
Protoxide of iron,	17·76	3·94

Or very nearly

1 atom titanic acid,
3 atoms peroide of iron,
1 atom protoxide of iron.

The mineral then is a tetratitaniate of iron, composed of

3 atoms tetratitaniated peroxide,
1 atom tetratitaniated protoxide.

The mean of the next four analyses gives us

		Atoms.
Titanic acid,	40·92	7·79
Peroxide of iron,	26·1	5·22
Protoxide of iron,	28·51	6·33

These numbers correspond nearly with

7 atoms titanic acid,
5 atoms peroxide of iron,
6 atoms protoxide of iron.

So that the mineral approaches a dititaniate of iron, and must be a compound of

5 atoms dititaniated peroxide,
6 atoms dititaniated protoxide.

The last analysis, if we allow every thing to be impurity except the titanic acid and peroxide of iron, exhibits a compound of

1 atom titanic acid,
5 atoms peroxide of iron.

It is therefore a pentatitaniated peroxide of iron.

Thus the analyses already made indicate at least three distinct species of titaniferous iron ore, and doubtless others will be discovered hereafter.

It is probable that this mineral is rather a double than a simple salt of iron, so that its proper place would be the next section. To this also may be referred *ilmenite*, which hitherto has been considered as a titaniferous iron ore, because the analyses of Mosander and Rose have sufficiently demonstrated that it is a double salt.

3. *Triple Salts of Iron.*

These are not numerous, though doubtless as the examination of ferruginous minerals is advanced, the number will increase.

Sp. 1. *Ankerite.*

Rohwand, rohe wand, rosszahn, wandstein of the Stirian and Carinthian miners, poratomous lime haloid of Mohs.

This mineral was first made a species by Mohs. It occurs in the Rathhausberg, in Salzburg, upon beds in mica slate, and in many places extending from Stiria all along the chain of the Alps.

Colour white, with various tints of grey, red and brown; streak white.

It occurs in rhomboidal crystals, with angles of 106° 12′; so that it differs sensibly from the fundamental form of calcareous spar.

Structure foliated; fracture uneven.

Slightly translucent. Brittle. Lustre pearly.

Hardness 3·5 to 4. Specific gravity 3·080.

It occurs often in twin crystals, and not unfrequently in granular masses. It is often mixed with calcareous spar.

Its constituents, as determined by the analysis of Berthier,[*] are

Carbonate of lime, .	51·1
Carbonate of magnesia,	25·7
Carbonate of iron, .	20·0
Carbonate of manganese,	3·0
	99·8

Uniting the carbonate of manganese with the carbonate of iron, these constituents are equivalent to

8 atoms carbonate of lime,
5 atoms carbonate of magnesia,
3 atoms carbonate of iron.

Before the blowpipe it becomes black, and acts on the magnetic needle.

Sp. 2. *Pyrosmalite.*[†]

This mineral was discovered by Messrs. Clason and Henry Gahn in the iron mine of Bjelke, at Nordmark, in Wermland. It was named by Haussmann, from the strong smell of chlorine which it emits when heated before the blowpipe.

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[*] Traité des Essais par la voie seche i. 494.

[†] From *πυρ*, *fire*, and *ὀσμη*, *odour*.

Colour externally liver-brown, internally light greenish-yellow; streak paler.

Found only crystallized in six-sided prisms, varying in length from a few lines to an inch, but seldom larger.

From the cleavage planes, the primary form appears to be the regular six-sided prism.

Fracture uneven, rather splintery.

Lustre pearly.

From translucent to opaque; rather brittle; hardness 4·5; specific gravity, as determined by Hisinger, 3·081.

Before the blowpipe it becomes blackish-red brown, and gives out fumes of muriatic acid. In a strong heat it melts into a black slag, which at last becomes a round globule, attracted by the magnet. Fuses easily and in considerable quantity in borax. The colour of the bead shows the presence of iron and manganese. In biphosphate of soda it fuses with great difficulty.

Its constituents, as determined by Hisinger and Berzelius,* are

		Atoms.
Silica,	35·850	17·92
Chlorine,	3·760	0·83
Peroxide of iron,	35·480	7·09
Sesquioxide of manganese,	23·444	4·69
Lime,	1·210	0·34
Water,	3·600	3·2
	103·344	

The increase of weight shows that in the mineral the iron and manganese are in the state of protoxides.

Pyrosmalite appears to be composed of sesquisilicates. The numbers approach to

7 atoms sesquisilicate of iron,
5 atoms sesquisilicate of manganese,
½ atom sesquichloride of iron,
3 atoms water.

Sp. 3. *Commingtonite.*

This mineral has been found at Commington, Massachusetts, in a rock which, judging of the specimen in my possession, is composed of quartz, garnet and commingtonite.

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* Afhandlingar, iv. 317.

Colour greyish-white.

In imperfectly crystallized masses, consisting of needles slightly diverging.

Lustre silky.

Opaque, or only translucent on the edges.

Hardness 2·75; specific gravity 3·2014.

Infusible per se before the blowpipe. With carbonate of soda fuses with effervescence into a dark glass. Fuses with borax or biphosphate of soda into a black glass bead, showing the presence of much iron and manganese.

Its constituents, determined by the analysis of Dr. Thomas Muir, in my laboratory, are as follows:

		Atoms.	
Silica, . .	56·543 .	28·27 .	16·34
Protoxide of iron,	21·669 .	4·81 .	2·78
Protoxide of mangan.,	7·802 .	1·73 .	1
Soda, . .	8·439 .	2·11 .	1·22
Moisture, . .	3·178 .	2·83 .	1·6
	97·631		

The bases are obviously in the state of tersilicates. The numbers approach

3 atoms tersilicate of iron,
$1\frac{1}{5}$ atom tersilicate of soda,
1 atom tersilicate of manganese,
$1\frac{1}{2}$ atom of water.

The formula is $3fS^5+NS^3+mnS^3+1\frac{1}{2}Aq$.

Sp. 4. *Nontronite.*[*]

This mineral was discovered at Nontron, in the department of Dordogne, about the year 1826. There is in that department an important deposite of manganese, known by the name of manganese of Peregueux, which occurs in nests in alluvial clay. The *nontronite* was found by M. Lanoue in this manganese, at the village of Saint Pardoux. It is disseminated in amorphous nodules, usually very small, and never larger than the fist. These nodules are never pure; they easily break into smaller pieces, quite irregular, and each enveloped in a thin black coating of manganese. They are often mixed with

[*] *Berthier,* *Ann.* de Chim. et de Phys. xxxvi. 22.

yellow micaceous clay; so that when a piece of the mineral is polished, it looks like serpentine.

Nontronite, when pure, has a straw-yellow colour, sometimes with a tint of green.

Massive and compact; fracture uneven and dull.

Opaque. Unctuous to the touch. Very friable.

Hardness scarcely 2.

Takes a good polish, and then has a resinous lustre; under the pestle it flattens and shows ductility, instead of falling into powder.

Does not exhale the odour of clay when breathed upon; does not act on the magnetic needle.

When plunged into water, numerous air bubbles are disengaged, and it becomes translucent on the edges, without losing its form or falling to powder. If it be taken out after some hours' immersion, and wiped dry and weighed, it will be found to have increased $\frac{1}{10}$th in weight.

When heated in a glass tube, it gives out water and becomes red.

It dissolves readily in muriatic acid.

Its constituents, as determined by Berthier, are as follows

		Atoms.
Silica,	44	22
Peroxide of iron,	29	6
Alumina,	3·6	1·6
Magnesia,	2·1	0·8
Water,	18·7	16·6
Clay,	1·2	
	98·6	

These numbers correspond with

$7\frac{1}{2}$ atoms tersilicated peroxide of iron,
2 atoms bisilicate of alumina,
1 atom silicate of magnesia,
20 atoms water.

The formula is $7\frac{1}{2}fS^3+2AlS^2+MS+20Aq$.

Sp. 5. *Volkonskoite.*

This mineral was discovered in Mount Jessmictski, in the district of Okhausks, and the government of Perne. It is found in thin veins and in nests.

Colour fine grass-green.

Texture compact.

Fracture conchoidal or uneven.

Dull; assumes a polish when rubbed by the fingers.

Very soft; feels smooth; specific gravity not given.

When heated in a glass tube, it gives out a good deal of water, and assumes the colour of goose dung. When calcined in a platinum crucible, it loses 32 per cent. of its weight, and assumes a brown colour like that of burnt coffee.

It gelatinizes with hot and concentrated muriatic acid, yet not more than half the chromium contained in the mineral is dissolved, the rest being left mixed with the silica.

The constituents of this mineral, as determined by the analysis of Berthier,[*] are

		Atoms.
Green oxide of chromium,	34·0	6·8
Peroxide of iron,	7·2	1·44
Magnesia,	7·2	2·88
Silica,	27·2	13·6
Water,	23·2	20·62
	98·8	

These numbers correspond with

4 atoms bisilicate of chromium,
2 atoms bisilicate of magnesia,
1 atom chromite of iron,
14 atoms water.

The formula is $4\mathrm{ChS}^2+\mathrm{MgS}^2\mathrm{f}\bar{\mathrm{C}}\mathrm{h}+14\mathrm{Aq}$.

But from the uncommon nature of these compounds, and the imperfect action of the muriatic acid, Berthier considers it as a mixture of hydrate of chromium, and silicate of iron and magnesia. Were we to adopt that view of its constitution, it would consist of

5 atoms terhydrate of chromium,
2 atoms tersilicate of magnesia,
1 atom tersilicate of iron.

But if this were the constitution of volkonskoite, no good reason could be assigned why only one half of the hydrate of chromium dissolves in muriatic acid.

Sp. 6. *Polylite.*[†]

The mineral to which I have given this name constitutes a bed about $\frac{1}{4}$th inch thick, in magnetic iron ore, at Hoboken, in New Jersey.

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[*] Memoires par Berthier, ii. 263.

[†] From πολυς, *many*, and λιθος, *a stone*, on account of the numerous *constituents of which it is* composed.

Colour black.

Composed of plates, but only one cleavage is discernible. It resembles *hornblende*, or still more nearly *arfvedsonite*, in its appearance.

Lustre vitreous and splendent.

Opaque; brittle.

Hardness 6·25; specific gravity 3·231.

Before the blowpipe becomes lighter coloured, but does not fuse. With carbonate of soda fuses with difficulty into a brown frit, transparent while red hot, but becoming opaque on cooling. With borax fuses very slowly into a black transparent glass.

Its constituents, determined by my analysis, are

		Atoms.
Silica,	40·040	20·02
Protoxide of iron,	34·080	7·5
Protoxide of manganese,	6·600	1·5
Alumina,	9·425	4·2
Lime,	11·540	3·3
Water,	0·399	
	102·084	

If we unite the protoxides of iron and manganese, these numbers give us the constitution of polylite as follows:

9 atoms silicates of iron and manganese,
4 atoms silicate of alumina,
$3\frac{1}{3}$ atoms bisilicate of lime.

The formula will be $9(\frac{5}{6}f+\frac{1}{8}\underline{m}n)S+4AlS+3\frac{1}{3}CalS^2$.

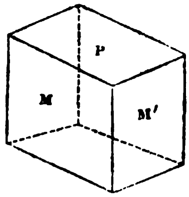
Sect. 3. *Sulphur Salts of Iron.*

These consist of combinations of one or more sulphur acids with one or more sulphuretted bases, one of which is always sulphuret of iron. Only two such salts are at present known, but doubtless the number will increase as the chemical examination of the different iron ores become more extensive and more complete.

Sp. 1. *Arsenical Pyrites.*

Mispickel, marcasite, sulpho-arsenite of iron.

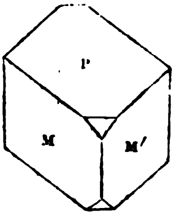
This mineral is pretty common both in beds and veins. It is accompanied by ores of silver, lead and tin. It is plentiful in some of the mining districts of Saxony and Bohemia. It occurs at Andreasberg in the Hartz, at Tunaberg in Sweden, at Huel Maudlin, and other mines in Cornwall, and in many other localities.



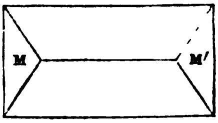
Colour silver-white, inclining to and passing into steel-grey; streak dark greyish-black.

It occurs massive and crystallized, in the form of a right rhombic prism,

M on M′ 111° 12′



This is the primary form. Sometimes (as in the second figure in the margin) the obtuse angles of the prism are replaced by triangular planes. When these become so large as to efface the bases of the prism, the crystal is converted into a kind of elongated octahedron, as in the third figure in the margin.



Lustre metallic; fracture uneven.

Opaque; brittle.

Hardness 4·75; specific gravity 6·127.

Before the blowpipe on charcoal it gives out a copious arsenical vapour, and the crystal becomes magnetic.

The constituents of this mineral are as follows:

Arsenic,	48·1	43·4	42·88
Iron	36·5	34·9	36·04
Sulphur,	15·4	20·1	21·08
	100*	98·4†	100‡

If we calculate from Stromeyer's analysis, we obtain

	Atoms.
Arsenic,	9·02
Iron,	10·2
Sulphur,	10·54

This approaches nearly to an atom of each constituent. Perhaps the mineral may be considered as composed of

$$\text{1 atom arseniet of iron, } \begin{cases} \text{1 atom arsenic,} \\ \text{1 atom iron,} \end{cases}$$

$$\text{1 atom sulphoarsenite of iron, } \begin{cases} \text{1 atom sulphide of arsenic,} \\ \text{1 atom sulphuret of iron.} \end{cases}$$

---

* By my analysis. † By Chevreul's analysis.

‡ *By Stromeyer's* analysis, Schweigger's Jour. x. 404.

Sp. 2. *Berthierite.*[*]

Haidingerite of Berthier.

This mineral occurs in veins near the village of Chazelle, in Auvergne. Attempts were made to work it, but the antimony obtained was so bad that it could not be sold. M. Berthier recognised it as a new mineral species, and gave it the name of Haidingerite; but as this name had been already appropriated to another mineral, Poggendorf substituted that of Berthierite, from the discoverer of the new species.

Colour iron black; surface often covered with iridescent spots.

Usually in masses, confusedly foliated, and much mixed with quartz, carbonate of lime, and iron pyrites. It exhibits occasionally the rudiments of prismatic crystals, which serve to distinguish it from sesquisulphide of antimony.

Specific gravity not determined.

Fuses readily before the blowpipe.

A portion of it, freed as much as possible from impurities, being analyzed by Berthier, gave the following constituents:

		Atoms.
Sulphur,	28·3	14·15
Antimony,	48·3	6·03
Iron,	14·9	4·25
Zinc,	0·3	0·07
Quartz,	3·2	
Iron pyrites,	3·2	
	98·2	

These atoms correspond very nearly with

1½ atom sesquisulphide of antimony,

1 atom sulphuret of iron.

It is therefore a sesquisulpho-antimonite of iron.

This is not the only compound of sesquisulphide of antimony and sulphuret of iron. Berthier has lately pointed out two more.[†]

The first of these is found in the mine of Martouret, at no great distance from Chazelle. It is homogeneous in appearance, though much mixed with stony matter. Its texture is fibrous, with the fibres parallel; cross fracture granular, and almost dull. The colour is grey-blue, but less blue, and having less lustre than sesquisulphide of antimony. Its constituents, by Berthier's analysis, are

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[*] [illegible], Ann. de Chim. et de Phys. xxxv. 351.

[†] [illegible] par Berthier, ii. 273.

		Atoms.
Gangue, . .	60·0	—
Sesquisulphide of antimony,	33·7	3·06
Sulphuret of iron, .	6·3	1·15
	100	

This is very nearly 3 atoms of sesquisulphide of antimony to 1 atom of sulpuret of iron. The mineral is therefore a

Tersulpho-antimonite of Iron.

The second species is found at Aglar, in the department de la Creuse. It is associated with sesquisulphide of antimony and with iron pyrites. It has an iron-grey colour; its fracture is granular and fibrous. Its composition, determined by the analysis of Berthier, is

		Atoms.
Quartz, . .	7	—
Sesquisulphide of antimony,	75	6·8
Sulphuret of iron, .	18	3·27
	100	

So that it is a compound of 2 atoms sesquisulphide of antimony and 1 atom of sulphuret of iron. It is therefore a

Bisulpho-antimonite of Iron.

GENUS XVI.—MANGANESE.

Manganese is also a very abundant metal, though much less so than iron. Having a great tendency to combine with oxygen, it never occurs in the metallic state, except when in combination with some other substance, as with sulphur or arsenic. The oxides of manganese are most abundant; and, being three in number, and variously mixed and united, that part of mineralogy constituted a perfect chaos, which was first reduced into order by the valuable labours of Haidinger, accompanied by the analytical investigations of Dr. Turner, which pointed out the constitution of the different species determined by the crystallographic skill of Haidinger.*

The species of manganese minerals at present known amount to about 24. About 11 of these consist of combinations of manganese with some simple substance, while the rest are salts, having oxide of manganese for at least a part of the base. We shall therefore subdivide this genus into two sections.

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* Edin. Trans. xi. 119 and 143.

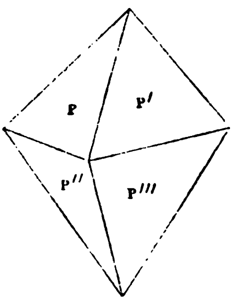
Sect. 1. *Manganese combined with Simple Bodies.*

Sp. 1. *Haussmannite.*

Red oxide of manganese, black manganese, pyramidal manganese.

This species has hitherto been found only in the porphyry formation near Ihlefeld in the Hartz. It is found in a vein by itself, as was first observed by Professor Gustavus Rose. It was first accurately described by Mr. Haidinger, and analyzed by Dr. Turner.

Colour brownish black; streak dark reddish or chestnut brown.



Massive and granular, also crystallized in octahedrons composed of two four-sided pyramids with square bases.

P on P′ or P″ on P‴, 105° 45′, according to the measurement of W. Phillips, 105° 25′, according to Haidinger.

P on P″, or P′ on P‴, 117° 30′, as measured by Phillips, 117° 34′, as by Haidinger.

The summits of the pyramids are sometimes replaced by low four-sided pyramids. Occurs often in twin crystals.

Lustre imperfect metallic; opaque.

Hardness 4·5 to 5; specific gravity 4·722.

Its constituents, as determined by Turner, are

Red oxide of manganese,*	98·098
Oxygen, . .	0·215
Water, . .	0·435
Barytes, . .	0·111
Silica, . .	0·337
	99·196

---

* This is the oxidum manganeso-manganicum of Arfvedson; a compound of

1 atom protoxide, . .	4·5
[illegible] atoms sesqui-oxide, .	10
	14·5

Admitting every thing but the red oxide to have been accidental impurity, this ore of manganese is analagous to magnetic iron in its composition. The shape of this last species is the regular octahedron, which differs considerably from the octahedron that constitutes the primary form of Haussmanite.

Sp. 2. *Braunite.*

Anhydrous sesqui-oxide of manganese. Brachytypous manganese ore.

This species was first recognised as peculiar by Mr. Haidinger, and to him we owe the first accurate descriptions of it. It occurs in veins in Thuringia, in the porphyry at Oehrenstock near Ilmenau, at Elgelsburg, Friedricksrode, and in other places. At Leimback in the county of Mansfield, it exists in cavities of white quartz, which appear to have been filled originally with some other substance. It occurs also at St. Marcel in Piedmont, in Wales, and near Launcestown, Cornwall; and doubtless in many other localities.

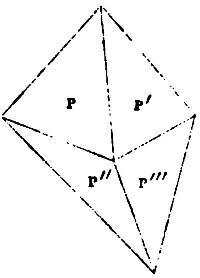
Colour dark brownish black; streak of the same colour.

Massive and crystallized. The primary form is an octahedron with a square base, differing exceedingly little from the regular octahedron. The inclination of the faces, according to Haidinger, are

P on P′, or P″ on P‴, 109° 53′
P on P″, or P′ on P‴, 108° 39′

Sometimes the summits of the pyramids are replaced by planes parallel to the base. Sometimes the two pyramids are separated by the intervention of a more acute octahedron, in which

P on P′ 96° 33′
P on P″ 140° 30′



Lustre imperfect metallic.

Opaque; brittle.

Hardness 6 to 6·5; specific gravity 4·818.

Its constituents, according to the analysis of Turner, are

		Atoms.
Protoxide of manganese,	86·940	19·22
Oxygen, . .	9·851	9·85
Water, . .	0·949	
Barytes, . .	2·260	
Silica, . .	trace	
	100	

The atoms of oxygen are very nearly half the atoms of protoxide of manganese. It is clear therefore, that the mineral consists essentially of sesquioxide of manganese.

Sp. 3. *Manganite.*

Hydrous sesquioxide of manganese.

This mineral occurs in great abundance in the manganese mines at Ihlfeld in the Hartz, in veins traversing porphyry. It is found likewise at Christiansand in Norway, and Udenäs in Sweden. Specimens of it in small specular crystals, have been brought from Nova Scotia.

Colour dark brownish-black, inclining to iron black; streak reddish-brown.

Occurs granular and columnar, and frequently crystallized. The primary form is a right rhombic prism of 100° and 80°. The edges of the prism are often replaced by one, or even two faces.

Lustre imperfect metallic.

Opaque in large masses; but in thin splinters it transmits a little light, and appears of a bright brown when held between the eye and the sun.

Brittle.

Hardness 4 to 4·25; specific gravity from 4·312 to 4·328.

Its constituents, according to the analysis of Turner, are

		Atoms.
Protoxide of manganese,	80·92 .	17·98
Oxygen, . . .	8·98 .	8·98
Water, . . .	10·10 .	8·97
	100	

It is obvious that the constitution of this mineral is

2 atoms sesquioxide of manganese,
1 atom water.

It is therefore a hydrous sesquioxide, and differs from the preceding species by containing water.

Sp. 4. *Pyrolusite.*

Grey ore of manganese, wad, anhydrous binoxide of manganese.

This is at once the most abundant and the most important of all the ores of manganese. It is found both in primary and secondary mountains. Many important mines of it occur in Thuringia. Ehrensdorf near Maehrisch Triebau, in Moravia, annually yields a great deal of it. Upton Pyne, near Exeter, supplies most of the manganese consumed in Great Britain, amounting annually to about 30,000 tons.

Colour iron-black.

Massive, columnar and crystallized in delicate needles, the form of which has not been made out. Haidinger gives the figure of a crystal in his possession, constituting a four-sided prism, with angles of about 86° 20′ and 93° 40′, the lateral edges of which are replaced by single planes.

Lustre metallic.

Rather sectile; opaque.

Hardness 2 to 2·8; specific gravity, when pure, 4·97; but it is as light as 4·819.

Its constituents are as follows:

	*	†	‡
Binoxide of manganese,	98·14	97·835	99·242
Water,	1·86	1·120	—
Barytes,	—	0·532	—
Silica,	—	0·513	0·840
Peroxide of iron,	—	—	0·130
	100	100	100·212

It is obvious from these analyses, that when pure it contains nothing but binoxide of manganese. Binoxide of manganese, when heated, lets go one-fourth of its oxygen, and is converted into sesquioxide. The atom of manganese being 3·5 and that of oxygen 1, it is obvious that the atom of binoxide weighs 5·5. It gives out, when heated, 0·5 oxygen and leaves 5 sesquioxide. So that this ore, when quite pure, gives out exactly the $\frac{1}{11}$th of its weight of oxygen. Hence the purity of such an ore is easily determined by the quantity of oxygen which it gives out.

Sp. 5. *Hydrous Binoxide of Manganese.*

This mineral was discovered by Berthier,[§] who found it in manganese from three different localities; namely, Groroi, in the department of Mayenne; Cautern, in the country of the Grisons, and Vecdessos, in the department of Arriege. In none of these places is it found pure, being always mixed with more or less of manganite or hydrous sesquioxide of manganese.

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[*] Arfvedson, Afhandlingar, vi. 229.

[†] Dr. Turner.

[‡] By my analysis. The specimen was very pure and crystallized in needles.

[§] Memoires par Berthier, ii. 230.

At Groroi the mineral is found in rounded pieces in a bed of sand and clay, which supplies the ironstone smelted in that department. It is in coherent pieces, full of small irregular holes.

Colour brownish-black; dull; here and there metallic. Its powder has a light chocolate colour. By ignition it loses 24 per cent. of its weight in water and oxygen without changing its form, but acquiring a reddish colour.

It dissolves slowly in concentrated sulphuric acid, and colours that acid a fine violet-red. Oxalic acid attacks it readily, even without heat. 2¼ times its weight of this acid are required to disoxidize it completely. Sulphurous acid dissolves it almost instantly. The constituents of the Groroi mineral, as determined by Berthier, are

		Atoms.
Protoxide of manganese,	62·4	13·86
Oxygen,	12·8	12·8
Water,	15·8	14·04
Peroxide of iron,	6·0	1·2
Clay,	3·0	
	100	

It is obvious that the whole protoxide of manganese in the mineral to be converted into deutoxide, would require 13·8 atoms of oxygen; but only 12·8 atoms were obtained. Hence the mineral must have been a mixture or compound of

11·8 atoms binoxide,
2 atoms sesquioxide,
14 atoms water.

It is obvious that every atom of the oxides of manganese in the mineral, was combined with an atom of water. The Groroi manganese then is a compound of

6 atoms binoxide of manganese,
1 atom sesquioxide of manganese,
7 atoms water.

Or if with Berthier we consider the sesquioxide as an accidental impurity, the constitution of the mineral will be

1 atom binoxide of manganese,
1 atom water.

The specimens from Vecdessoss and Cautern are similar to those from Groroi. The following are their constituents:

1. Vecdessoss.

		Atoms.
Protoxide of manganese,	68·9	15·31
Oxygen, . .	11·7	11·7
Water, . . .	12·4	11·02
Clay, . . .	7·0	
	100	

Obviously a compound of
8·1 atoms binoxide of manganese,
7·2 atoms sesquioxide of manganese,
11 atoms water.

Here the quantity of sesquioxide is much greater than in the last, and there is also a slight deficiency in the water.

2. Cautern.

		Atoms.
Protoxide of manganese,	46·5	10·33
Oxygen, . .	7·1	7·1
Water, . . .	8·8	7·82
Oxide of iron, .	3·6	
Quartz, . . .	33·6	
	99·6	

It is obvious that this mineral was a compound of
3·93 atoms binoxide of manganese,
6·4 atoms sesquioxide,
7·82 atoms water.

Here the proportion of sesquioxide is still farther increased, and there is also a deficiency in the water, though less than in the Vecdessoss specimen.

From this great variation in the quantity of sesquioxide in the different specimens, there can be little hesitation in adopting Berthier's opinion, that it is merely an accidental impurity.

Sp. 6. *Hydrous Sesquibinoxide of Manganese.*

This species, not hitherto noticed by mineralogists, seems to occur in considerable quantity in the neighbourhood of Cork. The proprietor some years ago brought a cargo of it to Glasgow for sale; on trial it was found to yield too little oxygen to answer the purposes of the manufacturer. I was induced to make a regular analysis of it, because it differed in its appearance from any of the ores of manganese which I had seen.

Colour brownish-black.

It was in small pieces, not much larger than the size of a pea, which were composed of fine particles.

Lustre imperfect metallic, almost dull.

Opaque.

Hardness 4·25; specific gravity 3·31245.

Its constituents, determined by three different analyses, are as follows:

		Atoms.	
Silica, . . .	22·90	11·45	7½
Sesquioxide of manganese,	23·48	4·69	3
Binoxide of manganese, .	17·22	3·13	2
Perox. of iron, with trace of copper,	28·64	5·73	4
Water, . . .	8·05	7·15	4·75
	100·29		

From the phenomena during the analysis, it was obvious that neither the silica nor the oxide of iron were in chemical combination with the manganese. The constitution (abstracting these two bodies) is

3 atoms sesquioxide of manganese,
2 atoms binoxide of manganese,
5 atoms water.

Each atom of the oxide of manganese was combined with an atom of water. It comes to be a question, whether the mineral now described be not a variety of Berthier's hydrous binoxide, which constitutes the last species. The circumstance of the proportions of the two oxides being to each other as 3 to 2, has induced me to place it separately.*

---

* Mr. Richardson lately analyzed, in my laboratory, a black ore of manganese from Muirkirk, having something of the metallic lustre, which seems to approach somewhat to the Cork ore; only it is much purer. Its specific gravity was 4·3479, and its constituents

		Atoms.	
Binoxide of manganese, .	52·69	12·12	3·03
Sesquioxide of manganese, .	33·41	8·46	2·11
Water, ...	2·92	3·27	0·82
Barytes, ...	7·49	1	0·25
Silica, ...	1·14		
Alumina, ...	0·74		
Peroxide of iron, . .	1·22		
	99·61		

Here the ratios approach that of 3 to 2. The water not amounting to an atom, the mineral was probably anhydrous. The barytes also is too

Sp. 7. *Varvacite.*[*]

This mineral occurs in Warwickshire, and was first noticed, named and analyzed, by Mr. R. Phillips.[†]

Colour grey, not differing much from that of pure binoxide, only less bright.

It is composed of thin plates and fibres, without any regular crystalline shape.

Lustre metallic.

Opaque.

Hardness 2·5; specific gravity from 4·283 to 4·531.

Its constituents, according to the analysis of Mr. Phillips, are

		Atoms.
Protoxide of manganese,	81·12 .	18·02
Oxygen, . . .	13·48 .	13·48
Water, . . .	5·40 .	4·8
	100	

These numbers are equivalent to

8·96 atoms binoxide of manganese,
9·08 atoms sesquioxide of manganese,
4·8 atoms water.

It is obvious that the constitution of varvacite (as Mr. Phillips has shown) is

2 atoms binoxide of manganese,
2 atoms sesquioxide of manganese,
1 atom water.

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small in quantity to constitute a chemical compound. Perhaps, from the absence of water, this specimen may be entitled to rank as a peculiar species. I shall therefore give a short description of it here.

The colour is bluish black, and it has something of the metallic lustre.

Texture compact and almost earthy; though there occur small particles in it having greater lustre than the rest, and exhibiting some slight indications of a foliated structure.

Fracture earthy and even.

It soils the fingers, yet it scratches calcareous spar, and has a hardness that may be estimated at 3·75; specific gravity 4·3479.

Not altered before the blowpipe per se, but when heated on charcoal it becomes brown, but does not melt.

With carbonate of soda fuses into a bluish green bead, opaque when cold.

With borax in the oxidizing flame, fuses into a transparent amethyst coloured bead, which becomes colourless in the reducing flame.

With biphosphate of soda the phenomena are the same.

[*] Because it occurs in the county of Warwick.

[†] Phil. Mag. (2d series), v. 209.

Thus we have a third compound of these two oxides in atomic proportions, and from the appearance and qualities of varvacite, there is every reason to consider it as a chemical combination.

Sp. 8. *Psilomelanite.*

This name has been given by Haidinger to a species of manganese ore, which has hitherto been confounded with *pyrolusite*, though it differs materially in its constitution from that species. It is one of the most generally diffused species, and often occurs mixed with Haussmannite and pyrolusite. In this way it is found in various parts of Germany, at Restormel in Cornwall, and at Upton Pyne, near Exeter.

Colour bluish black and greyish black, passing into dark steel grey; streak brownish black, shining.

Massive, reniform, botryoidal; but has not yet been observed in crystals.

Lustre imperfect, metallic.

Opaque; brittle.

Hardness 5 to 6; specific gravity 4·145.

Its constituents, according to the analysis of Dr. Turner, are

Red oxide of manganese,	69·795
Oxygen, . . .	7·364
Barytes, . . .	16·365
Silica, . . .	0·260
Water, . . .	6·216
	100

Red oxide being a compound of 4·5 protoxide of manganese, and 0·333 oxygen, it is obvious that 69·795 of it may be resolved into

Protoxide, .	64·966
Oxygen, .	4·829
	69·795

We may therefore represent the constituents thus:

		Atoms.
Protoxide of manganese,	64·966 .	14·44
Oxygen, . . .	12·193 .	12·19
Barytes, . . .	16·365 .	1·72
Silica, . . .	0·260	
Water, . . .	6·216 .	5·52
	100	

These numbers are equivalent to

	Atoms.
9·94 atoms binoxide of manganese, or	5·68
4·5 atoms sesquioxide, . .	2·57
1·75 atoms barytes, . .	1
5·52 atoms water, . . .	3·15

These atomic quantities may be perhaps considered as united in the following way:

$11\frac{1}{3}$ atoms binoxide,
2 atoms barytes, } 2 atoms sexmanganite of barytes.

$6\frac{1}{3}$ atoms water,
5 atoms sesquioxide, } 5 atoms hydrated sesquioxide.

I have ascertained by direct experiments, that binoxide of manganese combines with bases like an acid, and that the usual proportions combining, are six atoms of binoxide with one atom of base.*

Sp. 9. *Newkirkite.*

I give this name to a species of manganese ore which is found at Newkirchen in Alsace. It constitutes another of the many species long confounded under the name of *grey ore of manganese.*

Colour a brilliant black.

Lustre metallic, splendent.

Occurs in small needles which, when viewed through a powerful microscope, assume the appearance of a right rect-

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* Fuchs has analyzed a variety of this species, from Bayreuth, which contains potash as a constituent instead of barytes. Its constituents were

Protoxide of manganese,	81·8
Oxygen, . . .	9·5
Potash, . . .	4·5
Water, . . .	4·2
	100

This is obviously equivalent to

		Atoms.	
Sesquioxide of manganese,	86·24 .	17·25 .	23
Binoxide of manganese, .	5·06 .	0·92 .	1·22
Potash, ...	4·5 .	0·75 .	1
Water, ...	4·2 .	3·73 .	5
	100		

It is obvious at a glance, that the chemical constitution of this variety differs from that of the psimolenanite given in the text. See Berzelius, *Jahresbericht, 1833, p. 180.*

angular prism with a square base. But they are not susceptible of measurement. These needles form a coating on red hematite.

Opaque; rather sectile.

Hardness 3 to 3·5; specific gravity 3·824.

Its constituents, determined by the analysis of Mr. William Muir, in my laboratory, are as follows:

			Atoms.
Binoxide of manganese,	56·30	10·23	5·11
Peroxide of iron,	40·35	8·07	4·03
Water,	6·70	6	3
	103·35		

Perhaps the constitution of this mineral may be represented by

3 atoms water, } 3 atoms hydrated binoxide.
3 atoms binoxide, }
2 atoms binoxide, } 2 atoms biferrate of manganese.
4 atoms peroxide of iron, }

Sp. 10. *Sulphuret of Manganese.*

Manganblende. Swartzerz.

This rare mineral has hitherto been found only at Nagyag in Transylvania, in a vein accompanying tellurium ore; and according to Mr. W. Phillips, also in Cornwall.

Colour iron black; streak dark green.

Massive. It is said also to occur crystallized in cubes; surface rough.

Lustre imperfect metallic; opaque.

Hardness 3·5 to 4; specific gravity from 3·950 to 4·014.

Before the blowpipe it melts with difficulty, and only on its thinnest edges.

When reduced to powder and digested in muriatic acid, or dilute sulphuric acid, sulphuretted hydrogen gas is evolved. This proves that it is a sulphuret of manganese.

Arfvedson[*] has shown that it contains nothing but sulphur and manganese, and a trace of iron. By long exposure to heat he drove off the whole of the sulphur, and reduced the manganese to the state of *red oxide*. 4·94 parts of the mineral thus treated, became 4·25 parts of red oxide. But red oxide is composed of

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[*] Kong. Vet. Acad. Handl., 1822, p. 435.

Manganese,	.	3·5
Oxygen,	.	1·333
		4·833

Consequently 4·25 contain 3·077 manganese. Therefore the mineral is composed of

Manganese,	.	3·077 or 3·5
Sulphur,	.	1·863 or 2·119
		4·940

Or a little more than 1 atom of sulphur, united to 1 atom of manganese. If we consider the analysis as rigidly exact, then the mineral is a compound of

16 atoms sulphuret of manganese,
1 atom bisulphuret of manganese.

So that it resembles magnetic pyrites, which is a mixture or compound of sulphuret and bisulphuret of iron, in various proportions.

Sp. 11. *Arseniet of Manganese.*

This mineral has been noticed and examined by Mr. Robert John Kane, in Dublin.* The specimen was from Saxony, weighed about 2½ ounces, and was attached to a mass of galena.

Colour greyish-white.

Texture foliated.

Fracture in one direction uneven, fine, granular and shining; in the opposite direction it is dull and warty; and in that direction it breaks easily.

Hard; brittle.

Specific gravity 5·55.

Before the blowpipe it burns with a blue flame, and falls to powder. In a stronger heat, an arsenical fume rises and coats the charcoal with a white dust.

It dissolves in aqua regia without leaving any residue.

According to the analysis of Mr. Kane it is composed of

			Atoms.
Manganese,	45·5	.	13
Arsenic,	51·8	.	10·9
Iron,	trace		
	97·3		

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* *Quarterly* Journal of Sciences (new series), vi. 381.

Probably the loss was chiefly arsenic. It is not improbable therefore, that the mineral is a compound of

1 atom arsenic,
1 atom manganese.

It would, in that view of its constitution, be a simple arseniet of manganese.*

Sect. 2. *Oxygen Salts of Manganese.*

These amount to about eleven, and consist partly of simple salts, partly of double salts, and partly of triple salts.

1. *Simple Oxygen Salts.*

Sp. 1. *Carbonate of Manganese.*

Dialogite, rhodochrosite, and (when mixed with silicate of manganese) allagite, photizite, rhodonite.

This species occurs most commonly in veins along with the ores of silver, lead and copper. It is said also to have been found in transition mountains along with other ores of manganese. It is not uncommon in the Saxon mines, also at Nagyag and Kapnic, in Transylvania, near Elbingerode in the Hartz, &c.

Colour various shades of rose-red, partly inclining to brown; streak white.

Massive and crystallized in obtuse rhomboids, with angles of about 107° 20′, according to the measurement of Mr. Brooke.

Lustre vitreous, inclining to pearly.

Translucent in different degrees.

Brittle.

Hardness 3·5; specific gravity of the crystallized variety from Kapnic, as determined by Haidinger, 3·592.

Before the blowpipe its colour is changed into grey, brown or black, and it decrepitates strongly, but is infusible without addition. With borax it fuses into a violet-blue bead.

When exposed to the air, the natural colour is changed into brown.

It effervesces briskly in nitric acid.

Its constituents, according to the analysis of Du Menil,† are

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* Poggendorf's Annalen, xix. 145.

† Mohs' Mineralogy, ii. 107.

		Atoms.
Carbonic acid,	33·75	12·27
Protoxide of manganese,	54·60	12·13
Protoxide of iron,	1·87	0·41
Silica,	4·37	2·18
Lime,	2·50	0·71
	97·09	

It is obvious that it is a simple carbonate of manganese. The iron and lime are in the state of bisilicates, and only accidental impurities.

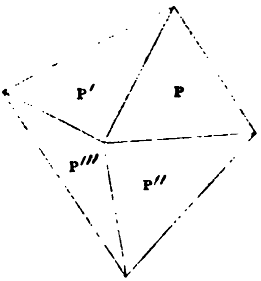
Sp. 2. *Disilicate of Manganese.*

Foliated black manganese ore.

Hitherto this mineral has only been met with in Piedmont, and it has been but imperfectly described. I have not myself had an opportunity of seeing it.

Colour iron black.

Massive, and crystallized in octahedrons.



P on P″ or P′ on P‴ 117° 30′

P on P′ or P″ on P‴ 105° 45′

according to the measurement of Mr. W. Phillips.

Powder brown.

Opaque; very hard.

Specific gravity not noticed.

On charcoal in a strong heat, it fuses on the edges and preserves its colour. With borax or biphosphate of soda it fuses easily, with the usual indications of manganese.

Its composition, as determined by Berzelius,* is

		Atoms.
Silica,	15·17	7·58
Red oxide of manganese,	75·80	15·47
Alumina,	2·80	1·24
Peroxide of iron,	4·14	0·81
	97·91	

If we admit the manganese in this mineral to be in the state of sesquioxide, it is obvious that during the analysis it sustained a loss of 2·6 oxygen, and that the sesquioxide amounted to 78·4 per cent., equivalent to 15·7 atoms; now the silica constitutes 7·58 atoms, or nearly the half. If, therefore, we admit the alumina, iron and small excess of silica to be accidental impurities, the mineral is a disilicate of sesquioxide of manganese.

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* Mineralogie, p. 277.

Sp. 3. *Silicate of Manganese.*

This species, so far as my information extends, has hitherto been found only at Franklin, in New Jersey. I got specimens of it from Dr. Torrey, about the year 1825. These specimens I subjected to analysis, and an account of the mineral was published by me in 1828, in the Annals of the Lyceum of Natural History of New York.

Colour light brownish-red.

Massive; structure foliated. Two cleavages are very distinct at right angles, or nearly so, to each other. There is a third cleavage perpendicular to the two others, but it is very imperfect. Hence the primary form seems to be a right oblique prism, which differs only by 3° or 4° from a right angle.

Lustre shining and vitreous; opaque.

Hardness 6·25; specific gravity 4·078.

Powder light red, becomes brown by ignition and loses 2·7 per cent. of its weight.

It dissolves, by digestion, in dilute muriatic acid without effervescence.

Its constituents, by my analysis, are as follows:

		Atoms.
Silica, . .	29·64 .	14·82
Protoxide of manganese,	66·60 .	14·8
Peroxide of iron,	0·92	
Moisture, .	2·70	
Alumina, .	trace	
	99·86	

Admitting the iron and moisture to be accidental impurities, it is obvious that the mineral is a silicate of manganese, composed of

1 atom silica,
1 atom protoxide of manganese.

Sp. 4. *Sesquisilicate of Manganese.*

This mineral, like the preceding, so far as I know, has been found hitherto only at Franklin, in New Jersey. I received several specimens of it from Dr. Torrey about the year 1825, but they were all very impure, and so mixed that it was not in my power to draw up accurate descriptions, or even to deduce proper consequences from the analyses which I made. One mineral, to which Dr. Torrey had given the name of *manganesian garnet*, I analyzed; but the specimen was very impure. I concluded that it is a compound of

4 atoms silicate of manganese,
1 atom silicate of iron,

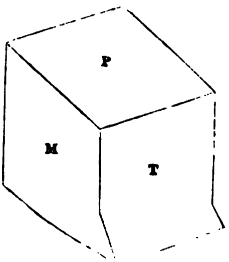
and therefore gave it the name of *ferrosilicate of manganese*. Under that name, an imperfect description, and analysis of it was published in the Annals of the Lyceum of New York for 1828.

Another of the specimens which I received from Dr. Torrey, was a mixture of small yellow grains (probably *garnet*,) and a blackish matter in scales or small plates. These plates I analyzed, and found them composed of *sesquisilicate of manganese*, mixed with a little sesquisilicate of iron. Under the name of *sesquisilicate of manganese*, an imperfect description and analysis of them is inserted in the same number of the Annals of the Lyceum.

Since that time, I have received much finer specimens of this mineral by the kindness of Mr. Nutall. These specimens enabled me to select much purer pieces for an analysis, than I had before. The result of a new investigation has been, that the mineral which I called *ferrosilicate of manganese*, is in reality a sesquisilicate, and consequently identical with the small black plates to which I had already given that name.

Colour brown, with a very slight shade of red.

Texture foliated. Crystallized in six or eight-sided prisms, which are said to be several inches in length, and an inch in diameter; but I have never seen any of these prisms. Texture foliated, with a threefold cleavage, indicating for the primary form of its crystal a doubly oblique prism. M on T (as near as I could measure by the common goniometer) 56° 30′. The inclination of P, the base of the prism, to the axis, is about *108°*.



Lustre vitreous, shining.

Opaque.

Hardness 6·25. Specific gravity 3·586.

The constituents, determined by the analysis of a very pure specimen, are

		Atoms	
Silica,	42·40	21·2	1·88
Protoxide of manganese,	50·72	11·27	1
Protoxide of iron,	6·76	1·5	0·13
	99·88		

This obviously corresponds with

8 atoms sesquisilicate of manganese,
1 atom tersilicate of iron.

And if we admit the tersilicate of iron to be an accidental impurity, the mineral will be a pure sesquisilicate of manganese.

Sp. 5. *Bisilicate of Manganese.*

Red mangankiesel.

This mineral was first observed at Longbanshyttan, Wermeland, Sweden. It was afterwards observed in Cornwall, in a manganese quarry about a mile and a half south-west of Callington. It occurs also on Blackdown, near Tavistock in Devonshire. I have specimens from the United States, and various other localities might be mentioned.

Colour rose-red, paler than that of the carbonate of manganese.

Massive. According to Rose two cleavages may be determined, making with each other an angle of about 87° 5′, which is the angle of *pyroxene.*

Fracture flat conchoidal.

Lustre intermediate between pearly and resinous.

Translucent on the edges; brittle.

Hardness 7; specific gravity, as determined by Berzelius, 3·538. I found that of a specimen from Franklin, New Jersey, 3·383, but it was impure.

Before the blowpipe it becomes dark brown, and fuses into a reddish-brown globule.

Its constituents are as follows:

Silica, . .	48·00	. 40·58
Protoxide of manganese,	48·98	. 38·92
Protoxide of iron,	trace	. 13·50
Lime, . .	3·12	. —
Magnesia, .	0·22	. —
Water, . .	—	. 3·00
Carbonic acid, .	—	. 3·23
	100·32*	99·23†

The specimen analyzed by Berzelius, which was obviously much purer than mine, gives the following numbers as the atomic constituents:

		Atoms.
Silica, . .	24	. 2·2
Protoxide of manganese,	10·88	. 1
Lime, . .	0·9	
Magnesia, .	0·08	

Admitting the lime and magnesia, and a small portion of the silica, to be accidental impurities, it is obvious that the mineral is a compound of

2 atoms silica,
1 atom protoxide of manganese.

Or it is a bisilicate of manganese.

In the American specimen analyzed by me, there existed a little carbonate of iron and a little bisilicate of iron, doubtless accidentally mixed with the bisilicate of manganese, which constituted the greatest portion of the mineral, and gave it its character.

2. *Double Salts.*

Sp. 1. *Huraulite.*

This mineral occurs at Hureaux in the Commune of St. Sylvester (Haute Vienne). It was found by M. Alluau about the year 1824, and sent to Vauquelin for analysis. Vauquelin inserted an analysis of it in the *Annales des Chimie et de Physique*.‡ Since that time, a more minute description and detached analysis have been published by M. Dufresnoy.§

Colour reddish yellow.

Crystallized. The crystals are small, not exceeding the head of a pin. Primary form a right oblique prism, with angles of 117° 30′ and 62° 30′. In most of the crystals this prism terminates in two faces, meeting like the roof of a house, and forming with each other an angle of 88°. Sometimes the oblique edges of the prism are replaced by tangent planes.

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* By Berzelius's analysis. The specimen was from Longbanshyttan. Schweigger's Jour. xxi. 254.

† By my analysis. The specimen was from Franklin, New Jersey.

‡ *Tom. xxx. p. 302.*

§ Ann. de Chim. et de Phys. xli. 338.

Lustre vitreous; transparent.

Rather hard; specific gravity 2·270.

Fuses readily before the blowpipe into a bluish bead, having the metallic lustre.

When heated gives out much water.

Its constituents, as determined by M. Dufresnoy, are

		Atoms.	
Phosphoric acid, .	38·00 .	8·44 .	6·8
Protoxide of iron, .	11·52 .	2·56 .	2·08
Protoxide of manganese,	33·305 .	7·40 .	6
Water, . .	18·00 .	16 .	13
	100·825		

These numbers approach pretty nearly to

6 atoms phosphate of manganese,
2 atoms diphosphate of iron,
13 atoms water.

This mineral constitutes a small vein in granite, in the neighbourhood of Limoges.

Sp. 2. *Bustamite.**

This mineral was first noticed as new, by M. Bustamente of Mexico. It occurs accompanied by quartz and manganese at Real de Minas de Fetela, and at Ionotlæ, in the province of Publa, Mexico.

It has the form of spherical masses, having a radiated or almost laminated structure. Its colour is pale grey, with a slight tint of green or red. Slightly translucent when in thin splinters. Hardness 6·5; specific gravity 3·12 to 3·25.

Its constituents, according to the analysis of Dumas, are

		Atoms.
Silica, ...	48·90 .	24·45
Protoxide of manganese,	36·06 .	8·01
Lime, ...	14·57 .	4·16
Protoxide of iron, . .	0·81 .	0·18
	100·34	

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* Ann. des Mines (2d series), i. 272.

These numbers are obviously equivalent to
2 atoms bisilicate of manganese,
1 atom silicate of lime.
The formula is $2mnS^2+CalS^2$.

Sp. 3. *Ferruginous Silicate of Manganese.*

This mineral occurs at Sparta in New Jersey, and was noticed and examined by Messrs. Keating and Vanuxem, according to whom, it is a *silicate of zinc.* I got specimens of it from Dr. Torrey, about the year 1825, examined its composition, and published an account of it under the name of *ferruginous silicate of manganese*, in the Annals of the Lyceum of Natural History of New York, for 1828.

Colour brown with a slight shade of red; powder flea brown.

It occurs crystallized in six-sided prisms, terminated by low three-sided pyramids. The faces and edges of these pyramids are imperfect and dull, as if they had undergone partial fusion or corrosion. Hence it is impossible to measure the angles. According to Dr. Troost, the primary form is a cube. From this shape it passes into the rhomboidal dodecahedron. But I do not see how a cube could be converted into a regular six-sided prism, terminated by trihedral summits. This seems to require a rhomboid for the primary form. My own measurements led to the inference, that the primary form is an obtuse rhomboid, with angles of 124° and 56°. But the crystals in my possession are so imperfect, that no confidence can be put in any conclusion founded on them.

Foliated; but rather imperfectly so, and I could make out no distinct cleavages.

External lustre glimmering, internal shining, semimetallic; opaque; brittle.

Hardness 2·25; specific gravity 3·014 to 3·034.

Dissolves with effervescence in muriatic acid, some carbonic acid gas being evolved.

I found it composed of

		Atoms.
Silica, . .	30·650 .	15·32
Protoxide of manganese,	46·215 .	10·27
Peroxide of iron, .	15·450 .	3·09
Moisture and carbonic acid,	7·300 .	6·48
	99·615	

By exposing 100 grains of the mineral to a red heat, I extricated from it 0·1 cubic inch of carbonic acid gas, 0·16 cubic inch of oxygen gas, and 0·74 cubic inch of azotic gas. It is obvious from this, that the quantity of carbonic acid is too small to enter into the calculation of the constituents of the mineral.

The atomic numbers approach

3 atoms silicate of manganese,
1 atom sesquisilicate of iron,
2 atoms water.

From the phenomena during the analysis, it was evident that a portion of the manganese was in the state of sesquioxide. A corresponding portion of the iron was of course in the state of protoxide. But the portion of the mineral in my possession was too small to enable me to investigate the subject more completely.

Sp. 4. *Carbo-Silicate of Manganese.*

Horn-mangan.

This species was discovered by mine-commissioner Jasche, at Ilsenberg in the Lower Hartz, and described by him in a small book published in 1807. It was subjected to a chemical analysis in 1819 by Dr. Du Mesnil of Wunstorf.* Soon after, an analysis by Dr. Rudolph Brandes, together with a description by Professor Germar of Hallé, was given to the public.†

Colour chestnut brown, yellowish brown, and sometimes greenish or even bluish grey.

Massive.

Fracture flat conchoidal, uneven and splintery.

Lustre glimmering or dull.

Translucent, at least on the edges.

Hard enough to scratch glass; brittle.

Specific gravity of the splintery variety, according to Germar, 3·89; of the conchoidal variety, according to Jasche, from 3·10 to 3·50.

Phosphoresces before the blowpipe, and softens on the edges. Gives a hyacinth red colour to borax.

Its constituents, according to the analysis of Brandes,‡ are as follows:

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* Gilbert's Annalen, lxi. 190. As M. du Mesnil's analyses are not accompanied by descriptions, it is not easy to identify his species. I have not, on that account, ventured to use his analysis in the text.

† Schweigger's Jour. xxvi. 103.

‡ Ibid. 121.

	*	†	‡
Silica,	34	31	35
Carbonic acid,	8	10	5
Protoxide of manganese,	54·857	54·929	57·162
Water,	2·0	1·5	2·50
Oxide of iron,	0·5	0·5	0·25
Lime,	trace	1·0	0·101
Alumina,	trace	0·5	0·25
	99·357	99·429	100·263

The following table exhibits the atomic numbers deduced from these analyses:

		Atoms.		Mean.
Silica,	17	15·5	17·5	17
Carbonic acid,	2·9	3·63	1·83	2·44
Protoxide of mangan.,	12·19	12·20	12·70	12·36

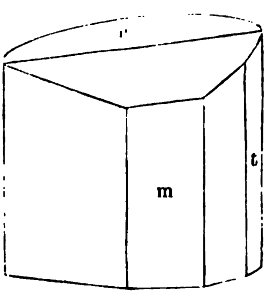
The mean of these numbers gives us pretty nearly (allowing for a small excess of manganese)

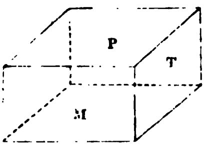
1 atom carbonate of manganese,
4 atoms bisilicate of manganese.

Sp. 5. *Babingtonite.*

This name was given by Mr. Levy to some crystals which he observed on *albite* from Arendal, which, from their shape, he considered as constituting a peculiar species.[§]

Colour black; lustre splendent, and probably vitreous.





The crystals were usually eight-sided prisms, as in the margin. In some, the plane m and the opposite plane were wanting, reducing the number of faces to six. These crystals cleave easily and with brilliant surfaces, parallel to the planes P, t. Mr. Levy considers the primary form to be a doubly oblique prism, in which

P on M 92° 34′
P on T 88°
M on T 112° 30′

Hard enough to scratch glass; opaque.

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* The conchoidal variety. † The uneven variety.

‡ The splintery variety. [§] Annals of Philosophy (2d series), vii. 275.

Specific gravity not determined.

Mr. Children[*] found its behaviour before the blowpipe as follows:

It decrepitates when heated in a glass tube, giving out water; but is not altered in its appearance.

Fuses per se into a black enamel.

With carbonate of soda in the oxidizing flame, it fuses into a dark green opaque globule, the colour of which is heightened by nitre. In the reducing flame, the colour became nearly black. To borax it gave a violet colour, which in the reducing flame became bluish green.

Mr. Children found the constituents to be silica, oxides of iron, and manganese, and lime; but the quantity of the mineral in his possession was not sufficient for a chemical analysis.

3. *Triple Salts of Manganese.*

Sp. 1. *Helvine.*

This mineral was discovered in 1815 or 1816, at Schwartzenberg in Saxony, in beds of talc slate in gneiss, by Mohs. It was named by Werner and described by Freisleben.

Colour wax yellow, inclining to honey yellow and yellowish brown. It is said also to have occasionally a siskin green colour; streak white.

It occurs in very small crystals, which appear at first sight to have the form of irregular octahedrons. According to Cordier, the primary form is an acute rhomboid, the plane angles of which are 72° and 108°. The two summits of this rhomboid are usually replaced by planes perpendicular to the axis. This face is inclined to the adjacent planes of the rhomboid at an angle of 105° 30′. Sometimes this truncature of the summit is slight, but in general it cuts off about $\frac{1}{3}$d of the axis at both extremities of the rhomboid, and thus converts it into an irregular octahedron.[†]

Lustre vitreous, inclining to resinous.

Translucent on the edges; fracture uneven.

Hardness 6·5; specific gravity, as determined by Gmelin, 3·166.

Before the blowpipe on charcoal, it melts in the reducing flame into a globule, having nearly the colour of the original assay. In the oxidizing flame the colour becomes dark, and the fusion more difficult. With borax it yields a transparent glass, often coloured by manganese.

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[*] Annals of Philosophy (2d series), vii. 277.

[†] Ann. des Mines, iii. 10.

It may be dissolved (if in powder) in muriatic acid, and sulphuretted hydrogen gas is given out abundantly.

It was analyzed by Professor C. G. Gmelin,* who obtained the following constituents:

		Atoms.	
Silica,	33·258	16·63	13·5
Glucina with some alumina,	12·029	3·7	3
Protoxide of manganese,	31·817	7·07	5·74
Protoxide of iron,	5·564	1·23	1
Sulphuret of manganese,	14·000	2·54	2·06
Loss by ignition,	1·155		
	97·823		

He examined the mineral for fluoric acid, but could detect none.

The presence of sulphuret of manganese, renders it difficult to form an accurate conception of the nature of this mineral. So far as we know at present, it does not enter into chemical combination with oxygen salts. We must therefore consider it as an accidental mixture. The other constituents seem to be

1 atom bisilicate of iron,
3 atoms bisilicate of glucina,
6 atoms silicate of manganese.

The sulphuret of manganese amounts to two atoms.

It would be desirable that the nature of this curious mineral could be still more completely investigated. But its scarcity has hitherto put it out of the power of chemists to make the requisite experiments on it.

GENUS XVII.—NICKEL.

The ores of nickel are few in number, and what is curious, the metal is rarely met with except in combination with sulphur or arsenic, or both. These ores occur most commonly in veins which traverse the primitive formations.

The species of nickel ores hitherto observed, amount only to eight. Of these, three are salts, and five combinations of nickel with sulphur or arsenic.

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* Poggendorf's Annalen, iii. 55.

1. *Nickel combined with Simple Bodies.*

Sp. 1. *Sulphuret of Nickel.*

Haarkies.

This mineral was first found in Adolphus mine at Johann Georgenstadt. It has been found also near Salzburgh, in the Hartz, and in Cornwall in Huel Chance mine, near St. Austle.

Colour intermediate between steel grey and brass yellow.

It occurs in small capillary crystals, the shape of which has not been ascertained.

Lustre metallic, shining; opaque; brittle.

Heavy; but the specific gravity has not been determined.

When heated in a glass tube it exhales sulphurous acid. On charcoal, before the blowpipe, it half melts into an agglutinated mass, which is metallic, malleable, and magnetic, and consists wholly of nickel.

Klaproth, from an analysis made by him, concluded it to be native nickel.[*] Berzelius having examined it by the blowpipe, concluded that it was a sulphuret of nickel. This opinion was confirmed by Arfvedson,[†] who subjected it to a chemical analysis, and found its constituents

		Atoms.
Sulphur,	34·26	17·13
Nickel,	64·35	19·8
	98·61	

This approaches pretty near

1 atom sulphur,
1 atom nickel.

Indeed the analysis comes much nearer these numbers than Arfvedson has allowed it. There is no reason to doubt, then, that haarkies is a simple sulphuret of nickel.

Sp. 2. *Arseniet of Nickel.*

Cupfer nickel.

This is the most common species of nickel ore. It occurs usually in veins; very rarely in beds. It is found both in primary and secondary rocks. Thus it occurs at Schneeberg, Annaberg, Marienberg, Freyberg, Gersdorf, and other places in Saxony, in various parts of Germany, at Allemont in Dauphiné; in Cornwall it is found in Pengelly mine, and in Huel Chance. In Scotland it has been found in the Leadhills, and at Wanlockhead. It is said also to have been met with in Linlithgowshire. Many other localities might be named.

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[*] Beitrage, v. 231.

[†] Kong. Vet. Acad. Handl., 1822, p. 443.

Colour copper red; streak pale brownish black.

Usually massive; but it is said to have been seen crystallized in six-sided prisms.

Fracture small conchoidal, uneven.

Lustre metallic; opaque; brittle.

Hardness 5·5; specific gravity 7·655.

Before the blowpipe on charcoal it emits arsenical fumes and melts into a bead, which darkens by exposure to the air.

The following table exhibits the constituents of this mineral according to the best analyses of it hitherto made:

	*	†	‡	Atoms.	
Nickel, .	48·90	39·94	44·206	13·6	1·18
Arsenic, .	46·42	48·80	54·726	11·5	1
Iron, . .	0·34	trace	0·337		
Sulphur, .	0·80	2	0·401		
Antimony, .	—	8	—		
Lead, .	0·56	—	0·320		
Cobalt, .	—	0·16	—		
	97·02	98·90	99·990		

The atoms, deduced from Stromeyer's analysis, (whose specimen was by far the purest,) lead to the conclusion that copper nickel is a compound of

1 atom arsenic,
1 atom nickel,

and that therefore it is a simple arseniet of nickel.

Sp. 3. *Subsesquiarseniet of Nickel.*

This mineral, though it has not been found native, but is only a produce of the smelting houses, deserves to be described on account of its character and constitution.

It occurs in crystals on the impure arseniet of nickel called *speiss.*

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* Pfaff, Schweigger's Jour. xxii. 256. The specimen was from Riegelsdorf, and obviously mixed with iron pyrites and galena.

† Berthier, Ann. des Mines, iv. 467. The specimen was from Allemont and obviously mixed with subsesquisulphide of antimony.

‡ *Stromeyer, as quoted* in Mohs' Mineralogy, ii. 447.

The colour is tombac brown, sometimes with a tint of steel blue.

In crystals. The shape is an octahedron with a square base. In general the summit of the pyramid is truncated, sometimes so deeply as to give the crystal the form of a table with bevelled edges.

Lustre shining, metallic.

Very brittle, easily reduced to powder, and not magnetic.

Opaque.

Specific gravity and hardness not given.

Before the blowpipe it behaves like arseniet of nickel.

The constituents of this mineral, determined by the analysis of Wöhler,* are

Arsenic,	44·1
Nickel,	52·7
Copper, iron, and manganese,	1·6
Sulphur,	1·65
	100·05

Or leaving out the accidental impurities,

			Atoms.
Arsenic,	45·87	9·65	1
Nickel,	54·13	16·65	1·75
	100·00		

These numbers approach sufficiently near

1 atom arsenic,

1½ atom nickel,

to leave no doubt about the constitution of the mineral. It is a subsesquiarseniet of nickel.

Sp. 4. *Binarseniet of Nickel.*

This mineral occurs at Schneeberg. It has been described and analyzed by Dr. Hoffmann.†

Colour tin-white.

Massive, and mixed with small concretions of quartz; fracture uneven.

Lustre metallic; opaque.

Surface often covered with a thin coating of diarseniate of nickel.

Its constituents are

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* Poggendorf's Annalen, xxv. 302.

† Ibid. xxv 491.

			Atoms.
Sulphur,	0·14	.	0·07
Copper,	0·50	.	0·12
Bismuth,	2·19	.	0·27
Arsenic,	71·30	.	15
Nickel,	28·14	.	8·65
	102·27		

Allowing the other constituents to be accidental, the mineral is a compound of

2 atoms arsenic,
1 atom nickel.

Or it is a *binarseniet of nickel.*

A variety of this mineral occurs in the cobalt mine of Riegelsdorf in Hesse, differing merely by containing a little cobalt. It is crystallized in hexahedrons, with the angles and edges truncated. Doubtless the primary form is a cube. The colour is tin-white.

Before the blowpipe, on charcoal, it gives out much arsenic, and fuses into a brittle metallic button. This button gives with borax a blue glass, indicating cobalt. If after this the button be fused with biphosphate of soda, we have the reaction of nickel; namely, a clove-brown transparent glass in the outer, and a brown opaque glass in the inner flame. Its constituents, as determined by the analysis of Mr. Booth, are

			Atoms.		
Nickel,	20·74	.	6·38	.	6·19
Cobalt,	3·37	.	1·03	.	1
Iron,	3·25	.	0·92	.	0·89
Arsenic,	72·64	.	15·29	.	14·84
	100*				

Obviously composed of

6 atoms binarseniet of nickel,
1 atom binarseniet of cobalt,
1 atom binarseniet of iron.

Sp. 5. *Antimoniet of Nickel.*

This mineral was discovered by M. Volkmar of Brunswick, it occurs in the Andreasberg mountains, associated with calcareous spar, galena and speiss cobalt, and has a strong resemblance to *copper nickel*, though it differs from it in colour.

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[*] *Poggendorf's* Annalen, xxxii. 395.

Colour in the fresh fracture light copper-red, inclining strongly to violet; powder reddish-brown.

Occurs crystallized in short six-sided prisms, which appear to be regular; sometimes they are terminated in six-sided pyramids.

Fracture uneven, passing into small conchoidal.

Lustre metallic, splendent.

Brittle.

About the hardness of copper nickel.

Specific gravity not determined.

Not acted on by the magnet.

Before the blowpipe some antimony sublimes.

Its constituents, as determined by Stromeyer, are

	1st Anal.	2nd Anal.	Atoms.	
Nickel, .	28·946	27·054	17·23	1·11
Antimony, .	63·734	59·706	15·43	1
Iron, . .	0·866	0·842		
Sulphuret of lead,	6·437	12·357		
	99·983	99·959		

The constituents are doubtless 1 atom nickel and 1 atom antimony.*

2. *Oxygen Salts.*

Sp. 1. *Diarseniate of Nickel.*

This salt has been observed at Allemont in Dauphiny, adhering to arseniet of nickel. It is supposed to be formed by the spontaneous decomposition of that mineral by the action of the air.

It is compact and has a fine apple-green colour. Its constituents, as determined by the analysis of Berthier,† are as follows:

		Atoms.	
Protoxide of nickel,	36·2	8·51	1·99
Protoxide of cobalt,	2·5	0·58	
Arsenic acid, .	36·8	5·07	1
Water, .	24·5	21·77	4·29
	100		

---

* Haussmann and Stromeyer, Poggendorf's Annalen, xxxi. 134.

† Ann. de Chim. et de Phys. xiii. 56.

If we reckon the oxide of cobalt along with that of nickel, the constitution is obviously

1 atom arsenic acid,
2 atoms protoxide of nickel,
4 atoms water.

It is therefore a hydrous diarseniate of nickel.

3. *Sulphur Salts of Nickel.*

Sp. 1. *Sulpho-Arsenide of Nickel.*

Nickel glance.

This mineral occurs at Loos in Helsingland. It was first noticed by Cronstedt;[*] but Pfaff[†] first described and analyzed it.

Colour tin-white; streak similar.

Massive; texture granular. In one variety the grains are rounder, in another they are less equal.

Lustre shining, metallic; opaque.

Hardness about 5; specific gravity 6·129.

When heated it decrepitates with great violence. When ignited in a glass tube, it leaves a matter similar to copper nickel, while sulphide of arsenic sublimes. Another variety, when heated in the same way, leaves a silver-white mass, and gives out also sulphide of arsenic.[‡] Berzelius[§] subjected it to four different analyses, conducted each a different way. The result is as follows:—

Arsenic, . .	55·50	53·32	48·06	45·37
Sulphur, . .	12·67	14·40	19·29	19·34
Nickel, . .	28·17	27·00	30·80	29·94
Iron, . .	3·63	5·29	2·99	4·11
Copper with cobalt,	—	—	—	0·92
Silica, . .	0·61	—	1·00	0·90
	100·58	100·01	102·14	100·58

The mean of these analyses gives us the following numbers:

		Atoms.
Arsenic,	50·56 .	10·64
Sulphur,	16·42 .	8·21
Nickel,	28·98 .	8·91
Iron,	4·00 .	1·14

---

[*] See Cronstedt's Mineralogy, by Magellan, ii. 342.

[†] Schweigger's *Jour.* xxii. 260.

[‡] *Berzelius, Kong. Vet.* Acad. Handl., 1820, p. 240.

[§] Ibid p. 241.

If we admit the iron to have been in combination with arsenic, and to have been accidental, it is obvious that the mineral contains

1 atom arsenic,
1 atom sulphur,
1 atom nickel.

If we double these atoms and consider the sulphur as combined with each of the bases, it is obvious that the two constituents of the mineral will be

$\left.\begin{array}{l}\text{1 atom sulphur,}\\ \text{2 atoms arsenic,}\end{array}\right\}$ making 1 atom disulphide of arsenic.

$\left.\begin{array}{l}\text{1 atom sulphur,}\\ \text{2 atoms nickel,}\end{array}\right\}$ making 1 atom disulphuret of nickel.

The first of these compounds is a sulphur acid, the second a sulphur base. Hence we may consider nickel glance as composed of

1 atom disulphide of arsenic,
1 atom disulphuret of nickel.

Sp. 2. *Sulpho-Antimonite of Nickel.*

This mineral was observed in Albertine, an old abandoned mine near Harzgerode, the working of which was resumed about the year 1825. It was particularly noticed by M. Zinken,* described by M. G. Rose,† and analyzed by M. H. Rose.‡

Colour white, exactly similar to that of arsenic pyrites.

Crystallized. The primary form is the cube. The angles of this cube are usually replaced by small planes. When these planes increase sufficiently, they convert the cube into the regular octahedron.

Lustre metallic, splendent; opaque.

Hardness 5·5; specific gravity 6·097.

Its constituents, determined by two analyses of H. Rose, are as follows:

			Mean.	Atoms.	
Sulphur,	15·98	15·55	15·76	7·88	1·14
Antimony,	55·76	54·47	55·11	6·88	1
Nickel,	27·36	28·04	27·70	12·31	1·79
	99·10	98·06			

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* Poggendorf's Annalen, xiii. 165.

† Ibid p. 167.

‡ Ibid xv. 590.

These numbers approach to

1 atom sulphur,
1 atom antimony,
2 atoms nickel.

The simplest way in which they can be supposed united is

1 atom antimony, } making 1 atom antimoniet of nickel.
1 atom nickel, }
1 atom sulphur, } making 1 atom sulphuret of nickel.
1 atom nickel, }

The mineral would appear to be a compound of

1 atom antimoniet of nickel,
1 atom sulphuret of nickel.

GENUS XVIII.—COBALT.

The ores of this metal are rather scarce, and they occur most frequently in the primary formations. Like nickel, it is almost always associated with arsenic or sulphur.

1. *Cobalt combined with Simple Bodies.*

Sp. 1. *Sulphuret of Cobalt.*

Cobaltkies, in part.

This mineral occurs at Bastnäs in Rydderhyttan, and was first noticed by Brandt, in 1746, who made several experiments on it and showed that it contained no arsenic.* It was noticed by Cronstedt, who refers to the observations of Brandt,† and by Bergmann, who refers to Cronstedt.‡ It constitutes one of the subspecies of Werner's *white speiss-cobalt;* but its true chemical nature has not been properly pointed out in any mineralogical work that I have seen.

Colour greyish-white or light steel-grey.

Massive; occurs in kidney-form or round pieces of various sizes, showing here and there some brilliant surfaces; but no crystalline shape can be detected.

Texture compact; fracture uneven and granular; lustre metallic; opaque.

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* Kong. Vet, Acad. Handl., 1746, p. 119.

† Magellan's Cronstedt, ii. 830.

‡ Sciographia, *p. 109.* *Withering's translation.*

Not attracted by the magnet unless it has been roasted.

Neither its hardness nor specific gravity have been determined.

When heated before the blowpipe it emits the smell of sulphur, without any mixture of an arsenical odour. It assumes a dark grey colour and melts into a bead, externally dark grey, but internally light grey, shining and brittle. After this treatment it gives with borax a dark blue glass and a white regulus, which is not attracted by the magnet unless it be pulverized.

It occurs in small quantities in the new Bastnäs mine, along with actinolite and copper pyrites.

Its constituents, determined by the analysis of Hisinger,* are

		Atoms.	
Cobalt,	43·20	13·29	1
Copper,	14·40	3·60	0·27
Iron,	3·53	1·00	0·07
Sulphur,	38·50	19·25	1·45
Gangue,	0·33		
	99·96		

If we consider the copper and iron as accidental impurities, which is exceedingly probable, the mineral is a compound of

$1\frac{1}{2}$ atom sulphur,
1 atom cobalt,

or a sesquisulphuret of cobalt.

If the iron be in the state of cubic pyrites, and the copper a common sulphuret, then the cobalt will be a simple sulphuret, or a compound of

1 atom sulphur,
1 atom cobalt.

Sp. 2. Sesquiarseniet of Cobalt.

Radiated white cobalt.

This mineral occurs at Schneeberg, in Saxony, and is noticed by Werner among the subdivisions of his *white cobalt.*

Colour tin-white, usually very dark, and inclining to grey.

Massive. Has not been observed in crystals.

Structure radiated; lustre metallic.

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* Afhandlingar, iii. 316.

Opaque; brittle; hardness 5·5.

Specific gravity not determined.

Its constituents, according to the analysis of John,* are

			Atoms.
Arsenic, .	65·75 .	13·84 .	1·60
Cobalt, .	28·00 .	8·61 .	1
Iron with manganese,	6·25 .	1·78 .	0·20
	100·00		

If we admit the iron to be in the state of diarseniet, it is obvious that the cobalt is combined with 1½ atom arsenic. The mineral therefore is a *sesquiarseniet of cobalt*, composed of

1½ atom arsenic,
1 atom cobalt.

Sp. 3. *Binarseniet of Cobalt.*

Speisscobalt in part. White cobalt ore.

This species occurs chiefly in veins traversing primary rocks. It is found in various parts of Saxony, as Schneeberg, Annaberg, Freiberg and Marienberg; also at Joachimsthal, in Bohemia, and at Huel Sparnan, in Cornwall. Various other localities might be mentioned.

Colour tin-white, inclining to steel-grey; streak greyish-black.

It occurs most commonly crystallized, and the primary form is the cube, with the same modifications which characterize iron pyrites. It cleaves in the direction of the cube, the octahedron, and rhomboidal dodecahedron.

Fracture uneven.

Faces usually smooth, subject to tarnish.

Lustre metallic.

Opaque; brittle.

Hardness 5·5; specific gravity 6·466.

Before the blowpipe emits copious arsenical fumes, and melts into a white metallic globule. To borax and other fluxes it imparts a blue colour.

It affords a pink solution in nitric acid, leaving a white residue, which is itself dissolved on farther digestion.

Its constituents are as follows:

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* As quoted in Mohs' Mineralogy, ii. 455.

	*	†	Atoms.	
Arsenic, ...	74·2174	70·37	15·62	16¼
Cobalt, ...	20·3135	13·95	6·25	6½
Iron, ...	3·4257	11·71	0·96	1
Copper, ...	0·1586	1·39	0·04	
Nickel, ...	—	1·79		
Bismuth, ...	—	0·01		
Sulphur, ...	0·8860	0·66	0·44	
	99·0012	99·88		

The specimen analyzed by Stromeyer being by far the purest, has been chosen for determining the atomic proportions.

If we admit that the copper, and a portion of the arsenic, are in the state of sulphurets, then the mineral will consist of binarseniets, and will consist of

6½ atoms binarseniet of cobalt,
1 atom binarseniet of iron.

Sp. 4. *Terarseniet of Cobalt.*

This mineral occurs at Schneeberg in Saxony. For its description and analysis, we are indebted to Mr. Ch. Karsten.[‡]

Colour lead-grey, sometimes steel-grey; texture radiated.

Lustre metallic, in some parts splendent, in others only slightly shining.

From the mixture of quartz grains, gives fire with steel.

Has no smell of arsenic. Specific gravity, owing to the mixture of quartz, varies from 4·5 to 4·7. If we abstract the quartz grains, it will be from 6·0 to 6·7.

Its constituents, (abstracting the quartz, which varies from 0·975 to 32·325 per cent.) are as follows:

		Atoms.
Arsenic, .	77·9602 .	16·41
Cobalt, .	9·8866 .	3·04
Iron, . .	4·7695 .	1·36
Bismuth, .	3·8866 .	0·48
Copper, .	1·3030 .	0·32
Nickel, .	1·1063 .	0·34
Sulphur, .	1·0160 .	0·51
Magnesia, .	trace	
	99·9282	

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* Stromeyer, Annals of Philosophy, x. 228.

† Ern. Hoffmann, Poggendorf's Annalen, xxv. 492. The specimen was from Sauschwart mine, Schneeberg, and was grey speisscobalt.

‡ Ann. des Mines (2d series), i. 548.

The sulphur and bizmuth nearly correspond. We may therefore consider that metal in the state of sulphuret; as also a small portion of the iron. The other constituents are obviously in the state of terarseniets, and the mineral consists of

9 atoms terarseniet of cobalt,
4 atoms terarseniet of iron,
1 atom terarseniet of copper,
1 atom terarseniet of nickel.

Should the terarseniets of copper and nickel be only accidentally present, then the mineral would consist of

9 atoms terarseniet of cobalt,
4 atoms terarseniet of iron.

The preceding four species are all arranged by Werner, under the name of *speisscobalt*.

Sp. 5. *Cobalt Ochre.*

This mineral occurs at Saalfield, Kamsdorf, and Glucksbrunn in Thuringia, and in various other places, along with cobalt pyrites.

Colour bluish and brownish-black, and blackish-brown.

Streak shining, even in the friable varieties, with a somewhat resinous lustre.

Botryoidal, stalactitical, massive.

Fracture conchoidal, very fine earthy.

Opaque; sectile; soils but little.

Soft, sometimes passing into very soft.

Specific gravity, as determined by Breithaupt, 2·200.

Before the blowpipe it gives out an arsenical smell, and colours borax smalt-blue.

It has not been analyzed; but is considered as a compound or mixture of the oxides of cobalt and manganese.

The *yellow* and *brown* cobalt ochres are probably only varieties of the black. But an accurate chemical examination will be necessary, before their identity or difference can be considered as established.

2. *Oxygen Salts.*

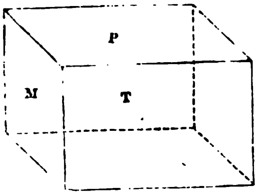
Sp. 1. *Diarseniate of Cobalt.*

Cobalt-bloom. Red cobalt ochre. Cobalt mica.

This mineral occurs in veins traversing rocks of various ages, and also in beds. The principal localities are Schneeberg and Annaberg in Saxony, Platten in Bohemia, Saalfield in Thuringia, &c.

Colour crimson-red, cochineal-red, peach-blossom red. Sometimes it is greenish-grey; streak corresponding to the colour, though a little paler.

It is found in botryoidal masses, and in short acicular diverging prisms, modified on the edges. The primary crystal is a right oblique prism.



M on T 124°.

According to the measurement of Mr. Brooke. The terminal edges of the prism are often replaced by one or more new faces.

Lustre of the base of the prism pearly, of the other faces adamantine, inclining to vitreous.

Varies from transparent to translucent on the edges.

Sectile; thin laminæ flexible.

Hardness 1·5 to 2; specific gravity 2·948.

Alone before the blowpipe it assumes a darker colour. On charcoal it gives out abundance of arsenical fumes, and melts into a bead of arseniet of cobalt. With borax and other fluxes it yields a fine blue glass.

Its constituents, according to the analysis of Bucholz,* are

			Atoms.
Arsenic acid,	37·9	5·22	1
Oxide of cobalt,	39·2	9·22	1·77
Water,	22·9	20·35	3·9
	100		

These numbers approach

1 atom diarseniate of cobalt,
4 atoms water.

It is therefore a hydrous diarseniate of cobalt. When all traces of crystallization disappear, the mineral is distinguished by the name of *cobalt crust.*

Disulphate of Cobalt.

Red vitriol.

This mineral occurs in the rubbish of old mines at Bieber, in the neighbourhood of Hanau.

Colour flesh-red and rose-red.

It occurs investing other minerals in small masses and stalactites.

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* Gehlen's Jour. (2d series), ix. 314.

Lustre vitreous.

Semitransparent to translucent.

Friable; taste astringent; soluble in water.

To glass of borax it communicates a blue colour.

Its constituents, according to Kopp,* are as follows:

			Atoms.
Sulphuric acid,	19·74	3·95	1
Protoxide of cobalt,	38·71	9·10	2·30
Water,	41·55	37	9·36
	100·00		

These numbers approach nearest to

1 atom disulphate of cobalt,
9 atoms water.

We may consider this salt therefore as a *hydrous disulphate of cobalt.*

3. *Sulphur Salts of Cobalt.*

Sp. 1. *Sulpho-Arsenide of Cobalt.*

Glance cobalt. Bright white cobalt ore.

This species occurs most commonly in veins. Tuneberg in Sweden is one of its best known localities. It occurs also at Modum in Norway, and at Botallick, near St. Just in Cornwall.

Colour silver-white, inclining to red; streak greyish-black.

Crystals cubes, and the usual modifications of them.

Fracture imperfect conchoidal, uneven. The surface of the cubes streaked in three directions.

Lustre metallic; opaque; brittle.

Hardness 5·5; specific gravity 6·298.

Before the blowpipe gives copious arsenical fumes, and melts only after being roasted.

Its constituents are as follows:

	†	‡	§	Atoms.
Cobalt,	36·7	44	33·1012	10·18
Arsenic,	49·0	55	43·4644	9·15
Iron,	5·6	—	3·2324	0·92
Sulphur,	6·5	0·5	20·0840	10·04
	97·8	99·5	99·8820	

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* Gehlen's Jour. (2d series), vi. 157. † Tassaert, Ann. de Chim. xxviii. 100.
‡ Klaproth, Beitrage, ii. 307. § Stromeyer, Annals of Philosophy, x. 228.

If we include the iron along with the arsenic, it is evident that these numbers correspond with

1 atom cobalt,
1 atom arsenic,
1 atom sulphur.

Doubling these numbers, we have

2 atoms cobalt, } making 1 atom disulphuret of cobalt.
1 atom sulphur, }
2 atoms arsenic, } making 1 atom disulphide of arsenic.
1 atom sulphur, }

The former of these is a sulphur base, the latter a sulphur acid.

The mineral may be conceived as a compound of

1 atom disulphide of arsenic,
1 atom disulphuret of cobalt.

It appears from the analysis of Wernekink,* that there is another species of cobalt ore usually confounded with the preceding species. He found its constituents

		Atoms.
Cobalt,	43·86	13·49
Iron,	5·31	1·51
Copper,	4·10	1·02
Sulphur,	41·00	20·5
Gangue,	0·67	
	94·94	

It is evident at first sight, that the mineral analyzed by Wernekink, is an impure variety of the first species described under the genus *cobalt;* and that it is either a sesquisulphuret or sulphuret of cobalt, according as we consider the other metals united or not with sulphur in the mineral.

The specimen analyzed was from Schwaben mine, near Musen in Siegenschen. Had he given a description, I have no doubt that it would have agreed with the first species of this genus.

GENUS XIX.—ZINC.

Zinc is rather an abundant metal, and accordingly occurs in commerce at rather a low price; yet its ores are far from numerous, at least when we compare them with those of iron, manganese, lead, and copper. Zinc ores are not found associated with those of any of the four preceding genera; but they almost always accompany those of lead, and sometimes, though more rarely, they are found along with those of copper. Zinc in the metallic state occurs only in combination. In the state of oxide, it constitutes certain salts by entering into combination with an acid.

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* Schweigger's Jahrbuch, ix. 306.

1. *Zinc combined with Simple Bodies.*

Sp. 1. *Blende, or Sulphuret of Zinc.*

Black Jack.

This mineral is very abundant in nature. It exists both in primary and secondary formations, and both in beds and in veins. It almost always accompanies the ores of lead, and frequently those of copper and tin. Hence it abounds in Cornwall and in Cumberland, Northumberland, Durham, Yorkshire, and Derbyshire. Many other localities might be pointed out, both in Great Britain and on the Continent.

Colour when pure, yellow; but it is often green, red, brown and black, owing to the presence of foreign bodies. None of these colours except the black, is bright. Streak corresponding with the colour.

Structure foliated, and it often occurs crystallized. The primary form is the rhombic dodecahedron, similar to that of garnet. The alternate angles of this dodecahedron are sometimes replaced by triangular faces. These increasing so as to cover the original faces, convert the crystal into the regular octahedron. The angles of this octahedron are occasionally replaced by tangent planes, which, when they increase sufficiently in size, convert the crystal into a cube. These three forms, the rhomboidal dodecahedron, the octahedron and cube, with their usual modifications, constitute the various forms of crystallization which blende assumes.

Lustre adamantine.

Transparent to translucent. The black varieties are often opaque; brittle.

Hardness 3·75; specific gravity 4·049.

Does not melt per se before the blowpipe, but gives out fumes of zinc, which form a white coating on the charcoal.

The following table exhibits the constituents of this ore, as determined by analysis:

	*	†	‡	‡	‡	‡	§	§
Zinc,	66·34	55·2	63·0	61·5	50·2	42·3	66	66·63
Iron,	—	8·6	3·4	4·0	10·8	7·3	1·372	20·74
Lead,	—	—	—	—	—	3·0	—	—
Sulphur,	33·66	36·2	33·6	33·0	30·2	25·9	32·628	32·63
Gangue,	—	—	—	1·5	6·8	21·4	—	—
	100	100	100	100	98	99·9	100	100

These numbers obviously correspond with

1 atom sulphur,
1 atom zinc.

Blende then is a simple sulphuret of zinc.

Sp. 2. *Voltzine.*

Oxysulphuret of zinc.

This mineral occurs at Rosiers, near Pont-Gibaud, in the department of Puy de Dome. It is found in a vein coating the other substances which fill the vein.

It occurs in the form of hemispherical tubercles, divisible into very thin coats, but having a conchoidal and irregular fracture.

Opaque, or feebly translucent.

Lustre pearly on the natural coats, but vitreous or resinous in other directions.

Colour yellowish red, interspersed with brown bands, seemingly coloured by an organic matter.

Hardness 4·5; specific gravity 3·66.

Its constituents, as analyzed by M. Fournet, to whom we are indebted for our knowledge of this mineral, are

			Atoms.
Sulphuret of zinc,	81·0	12·96	4·54
Oxide of zinc,	15·0	2·85	1
Oxide of iron,	1·8	0·36	
Organic matter,	2·2		
	100·0		

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* Arfvedson, Kong. Vet. Acad. Handl., 1822, p. 438.

† Lecanu, Ann. des Mines, ix. 418. It was a brown red lamellar blende from Cheronies.

‡ Berthier, ibid. p. 420. The first specimen a brown blende, from Luchon, Pyrenees. The second, a dark grey specimen, from England. The third, a brown blende, from Cagolin, department of the Var. The fourth, a brown blende, from Argentiere.

§ By my analysis.

Hence the component parts are

4½ atoms sulphuret of zinc,
1 atom oxide of zinc.

It was called Voltzite in honour of M. Voltz, engineer in chief of mines.

Sp. 3. *Seleniet of Zinc.*

This mineral was discovered in the mining district of Mexico, called El Doctor, and was examined and its nature discovered by Professor Del Rio, in 1817.

It has a grey colour, the metallic lustre, is opaque, and has a specific gravity of 5·56. Before the blowpipe it burns with a fine violet coloured flame, and exhales a strong smell, similar to that of rotten cabbage. When heated in a retort, selenium, mercury, and a little sulphur sublimes, and there remains an oxide of zinc easily soluble in acids.

Its constituents, according to the analysis of Del Rio, are as follows:

			Atoms.
Selenium,	49	9·8	6·2
Zinc,	24	5·64	3·57
Mercury,	19	1·58	1
Sulphur,	1·5	0·75	0·47
Lime,	6		
	99·5		

The lime was an accidental impurity, derived from the gangue of the mineral. These numbers approach nearest to

3½ atoms biseleniet of zinc,
1 atom disulphuret of mercury.

Whether the disulphuret of mercury be in combination with the biseleniet of zinc, or only mechanically mixed with it, has not been ascertained.

Sp. 4. *Red Zinc.*

Manganesian oxide of zinc.

This mineral has hitherto been found only in Sussex county, New Jersey, where it occurs in considerable quantities in several localities, probably in beds. It was first noticed, described, and analyzed by Dr. Bruce.

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[*] Ann. des Mines (3d series), iii. 519.

Colour bright red, with a shade of yellow; streak orange yellow.

Occurs in grains which are foliated, and cleave in the direction of a regular six-sided prism, according to Mr. W. Phillips.

Cross fracture conchoidal; brittle.

Lustre adamantine.

Translucent; in thin plates transparent.

Hardness 4; specific gravity 5·432.

When exposed to the air it becomes dull, and is covered with a white coating.

Infusible per se before the blowpipe; but it gives a yellow transparent glass with borax.

Soluble in nitric acid without effervescence.

Its constituents, as determined by Berthier,* are

			Atoms.
Oxide of zinc,	88	16·58	6·9
Sesquioxide of manganese,	12	2·4	1
	100		

These numbers correspond with

7 atoms oxide of zinc,
1 atom sesquioxide of manganese,

which must be the constitution of this mineral.

The colour of the mineral, and the difficulty of separating the two constituents from each other, show that the mineral is a chemical compound. The oxide of iron found by Bruce was doubtless owing to the impurity of the specimen selected for analysis, for red zinc occurs imbedded in Franklinite.

2. *Oxygen Salts of Zinc.*

Sp. 1. *Anhydrous Carbonate of Zinc.*

Calamine in part.

This mineral is rather abundant, and is found both in veins and beds, especially in company with galena and blende. It was first accurately distinguished by Mr. Smithson.

Colour white, though seldom pure. Generally grey, green or brown; streak white.

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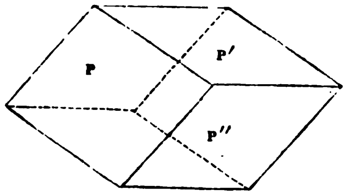
* Ann. des Mines, iv. 483.



It occurs frequently in crystals. The primary form is an obtuse rhomboid.

P on P′ 107° 40′ according to the measurement of Dr. Wollaston. It occurs also in acute rhomboids, and in long quadrilateral tables.

Structure foliated; fracture imperfect conchoidal.

Lustre vitreous, inclining to pearly; semitransparent to translucent; brittle.

Hardness 5; specific gravity, according to Smithson, 4·334. Haidinger found that of a honey-yellow crystallized variety, from Aix-la-Chapelle, 4·442.

Before the blowpipe it loses its transparency, but is infusible. The carbonic acid is driven off, and the residue acts like pure oxide of zinc.

It becomes negatively electric by friction; dissolves in acids with effervescence.

Its constituents, as determined by Smithson, are

	*	*	Mean.	Atoms.
Carbonic acid,	35·2	34·8	35	12·72
Oxide of zinc,	64·8	65·2	65	12·34
	100	100	100	

It is obviously a compound of

1 atom carbonic acid,
1 atom oxide of zinc.

It is therefore a simple carbonate of zinc.

Sp. 2. *Hydrous Dicarbonate of Zinc.*

Calamine in part.

This species frequently accompanies the preceding one. It has never been observed in crystals, but usually encrusts other minerals. It has somewhat the appearance of chalk, with a finer grain and closer texture.

Colour white or greyish, or yellowish-white.

Massive, or encrusting other bodies.

Dull; opaque.

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* Nicholson's Jour. vi. 76. The first specimen was from Somersetshire; it was greenish-yellow, and had a crystalline texture. The second was from *Derbyshire ; it was* pale yellow, and in small rhomboids.

Hardness 2 to 2·5; specific gravity, as determined by Smithson, 3·584 to 3·598.

Does not phosphoresce when scraped.

When plunged into water it absorbs about one-third of its weight of that liquid.

Before the blowpipe it becomes yellow, but recovers its colour on cooling. Before the reducing flame it is entirely dissipated, abundance of flowers of zinc being deposited on the charcoal. With borax and biphosphate of soda it fuses with effervescence into a clear colourless glass, which becomes opaque on cooling, if over saturated. Carbonate of soda has no action on it.

Its constituents, as determined by Smithson,* are

			Atoms.
Carbonic acid,	13·52	4·91	1
Oxide of zinc,	69·36	13·21	2·69
Water,	15·10	13·42	2·73
	97·98		

If we make allowance for a small deficiency of carbonic acid, the constituents are obviously

1 atom carbonic acid,
2 atoms oxide of zinc,
2 atoms water.

It is therefore a hydrous dicarbonate of zinc.

Sp. 3. *Anhydrous Silicate of Zinc.*

Williamsite.

The only specimen of this mineral which I have seen was purchased from a mineral dealer, who informed me that its locality was Switzerland, and that it had been called Williamsite by Mr. Levy.

Colour various shades of yellow, in different parts of the specimen, always inclining strongly to brown; powder light yellow.

An amorphous mass, studded with small crystals which had the aspect of right-angled prisms, but their surfaces were so rough that they could not be measured, even by the common goniometer; fracture granular and uneven.

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* Nicholson's Jour. vi. 74. The specimen analyzed was from Bleyberg. I have corrected Smithson's numbers by applying more correct data to his analysis.

Lustre resinous; brittle. Crystals varying from transparent to translucent. Mass translucent only on the edges.

Hardness 5; specific gravity 3·935.

Action of the blowpipe the same as in the next species.

I subjected it to analysis, and found the constituents

		Atoms.
Oxide of zinc, . .	68·77 .	13·09
Silica, . . .	26·97 .	13·48
Peroxide of iron, .	1·48	
Alumina, . . .	0·66	
Ditto, with a trace of zinc and iron,	0·78	
Water, . . .	1·25	
	99·91	

It is obvious enough that the essential constituents are silica and oxide of zinc. The other bodies are accidental impurities. The mineral is a simple anhydrous silicate of zinc.

The mineral dealer from whom I purchased the specimen, put into my hands the following analysis, made, he told me, by Mr. Levy:

		Atoms.
Silica, .	27·67 .	13·83
Oxide of zinc,	72·33 .	13·79
	100	

This analysis must have been made upon a purer specimen than mine, but it confirms the constitution of the mineral as just stated.

Sp. 4. *Hydrous Silicate of Zinc.*

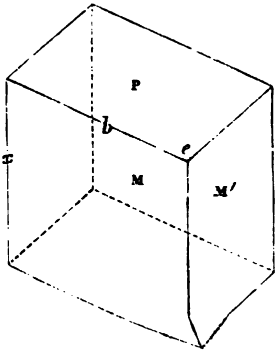
Calamine in part—electric calamine.

This species occurs in the same localities as the carbonate of zinc. It is more common in calcareous rocks than in any others. Bleiberg and Raibell, in Carinthia, are well-known localities. It is pretty common in England, and occurs at Leadhills and Wanlockhead, in Scotland.

Colour most commonly white; occasionally blue, green, yellow or brown; streak white.

It occurs massive, stalactitical and crystallized. The primary form is a right rhombic prism.

M on M′ 102° 35′



The crystals are seldom solitary, but disposed in radiated groups.

The edge *x* is often replaced by a face making an angle of 128° 40′ with M. The angle *e* is frequently replaced by a tangent plane, and the edge *b* and its opposite being replaced each by a plane, cause the extremity of the prism to terminate in two faces inclined to each other like the roof of a house.

Structure foliated or radiated.

Lustre vitreous, inclining to pearly on the base of the primary prism.

Brittle; transparent to translucent.

Hardness 5; specific gravity, according to Smithson, 3·434; according to Haidinger, 3·379.

Before the blowpipe decrepitates and emits a green light, but does not fuse. With borax or biphosphate of soda it fuses without effervescence, into a clear colourless glass; not acted on by carbonate of soda.

Becomes electric by heat; gelatinizes in nitric or muriatic acid.

Its constituents are as follows:

	[*]	[†]	Atoms.
Silica,	25·0	24·893	12·44
Oxide of zinc,	68·3	66·837	12·73
Water,	4·4	7·460	6·63
Carbonic acid,	—	0·450	
Oxides of lead and tin,	—	0·276	
	97·7	99·916	

It is obviously a hydrous silicate of zinc, composed of

1 atom silica,
1 atom oxide of zinc,
$\frac{1}{2}$ atom water.

Sp. 5. *Sulphate of Zinc.*

White vitriol—gallizenstein.

This salt occurs at Rammelsberg, near Goslar in the Hartz, at Schemnitz in Hungary, at Fahlun in Sweden, and at Holywell in Flintshire.

Colour white, sometimes inclining to peach-blossom red and violet-blue; pale; streak white.

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[*] Smithson, Nicholson's Jour. vi. 78.

[†] Berzelius, Kong. Vet. Acad. Handl., 1819, p. 141.

Occurs massive, stalactitical and investing other bodies. It is said also to occur crystallized in rectangular prisms, terminated by four-sided pyramids.

Lustre vitreous; transparent to translucent; brittle.

Hardness 2 to 2·5; specific gravity 2·036, as determined by Haidinger.

Taste astringent, metallic and very nauseous; soluble in water.

Before the blowpipe froths and covers the charcoal with white flocks.

A specimen from Rammelsberg, analyzed by Klaproth,* was composed of

		Atoms.	
Sulphuric acid,	22·7	4·7	1
Oxide of zinc,	27·5	5·23	1·11
Sesquioxide of manganese,	0·5	—	—
Water,	49·3	43·83	9·32
	100·0		

These numbers approach most nearly to

1 atom sulphuric acid,
1 atom oxide of zinc,
9 atoms water.

If the analysis be correct, the native sulphate contains more water than the artificial in crystals, which contains only 7 atoms of water.

Sp. 6. *Hopeite.*†

Dr. Brewster has given this name to some crystals observed on a mineral from a calamine mine at Altenberg, near Aix-la-Chapelle.

Its colour is white.

The crystals were four-sided prisms terminated by a truncated six-sided low pyramid. The primary form seems to be a right oblique prism with angles of 81° 34′.

It is transparent, and has two axes of double refraction.

Hardness 2·5; specific gravity 2·76.

When heated it gives out a great deal of water without any trace of carbonic acid. Before the blowpipe it becomes milk-white, and melts into a clear colourless globule, which gives the flame a greenish tint. With biphosphate of soda it melts in all proportions into a clear colourless glass, without any siliceous residue. With borax it fuses into a clear colourless glass, which does not become opaque on cooling. With carbonate of soda it gives a scoria, which when hot is of a yellowish colour. The oxide of zinc is condensed round it in great quantity on the charcoal, and next the scoria is a reddish yellow tint, which does not vanish on cooling, and indicates the presence of cadmium. When melted with soda and moistened, it exhales no hepatic odour. A solution of cobalt communicates a fine bluish tint to the melted assay.

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* Beitrage, v. 193. Correcting the sulphuric acid by the atomic numbers.

† Edin. Phil. Trans. x. 107. Named in honour of Dr. Hope, Professor *of Chemistry in Edinburgh.*

Hopeite is soluble without effervescence in muriatic and nitric acids. It dissolves also, though slowly, in sulphuric acid.

It seems probable from these phenomena, that Hopeite is a hydrous phosphate of zinc, with some cadmium.

3. *Sulphur Salts.*

Sp. 1. *Marmatite.*[*]

It is not improbable that black blende is frequently a chemical compound of sulphuret of zinc and sulphuret of iron, in which in all probability the sulphuret of iron acts the part of an acid, and the sulphuret of zinc that of an alkali or base. This at any rate seems to be the case with the black blende of Marmato, in the Province of Popayan, which was subjected to a chemical analysis by M. Boussingault. He extracted from two varieties of it the following constituents:

	Blende of Candado.	Blende of Salto.	Mean.	Atoms.	
Zinc, . . .	43·0	41·8	42·4	9·97	2·36
Iron, . . .	15·7	13·9	14·75	4·21	1
Sulphur, . . .	28·6	27·8	28·2	14·1	3·34
Pyrites, . . .	1·7	4·6	3·15		
Quartz, . . .	8·0	8·7	8·35		
Alumina, . .	—	0·9			
Oxide of manganese,	—	0·2			
Oxygen, . .	1·7	0·9			
	98·7	98·8			

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[*] Ann. de Chim. et de Phys. xliii. 312. Named from Marmato, where e mineral was discovered.

It is obvious that the sulphur just saturates the zinc and the iron, and that the atoms of zinc are to those of iron as 7 to 3. Hence the mineral is a compound of

7 atoms sulphuret of zinc,
3 atoms sulphuret of iron.

GENUS XX.—LEAD.

This metal is more abundant than any other, if we except iron, and perhaps manganese. Its ores are numerous and beautiful. They are most commonly in veins, and occur in every kind of formation; though perhaps they are more abundant in the transition and secondary rocks than in the primary. The species of lead ores at present known amount to 34. They may be conveniently subdivided in the same way as the preceding genus.

1. *Native or United to Simple Bodies.*

Sp. 1. *Native Lead.*

It has been doubted by mineralogists whether lead occurs *native* in the mineral kingdom. But several of the statements which have appeared are too well authenticated to be doubted. The pieces of lead described by Dr. Morris, as found in one of his fields in Monmouthshire, may perhaps have been accidentally deposited.* But it has been found in small masses in the lava of Madeira.† Native lead has also been found lately in the neighbourhood of Alston, in Cumberland. It occurs in small globular masses, imbedded in galena and a slaggy substance, accompanied by red oxide of lead, crystals of blende and quartz. The vein in which it is found traverses limestone. It is about an inch thick, but widens to two or three inches as it descends. The whole mass within the vein is considerably decomposed, and the ore is found in incoherent pieces, some of which are about the size of a walnut. Many of them have a very slaggy appearance both externally and internally, while others are pure galena, distinctly cleavable, and coated by a white meally sulphate of lead produced by decomposition.‡

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* Phil. Trans. 1773, p. 20.

† Phillips' Mineralogy, p. 332.

‡ Annals of Philosophy (second series), ix. 154.

Sp. 2. *Protoxide of Lead.*

Bleiglötte.

The existence of this species was first pointed out by Mr. Smithson. It is said to occur at Badenweiler, in Baden, in quartz. It has been described and analyzed by Dr. John.[*] Geralt states that it has been thrown out from the volcanoes of Papocatapell and Iztaccituatl, in Mexico.[†]

Colour intermediate between sulphur and lemon yellow; streak lighter.

Massive; fracture in one direction earthy, in another foliated, with a threefold cleavage, indicating a four-sided prism or rhomboid for its primary form.

External lustre dull, internal semimetallic.

Opaque; semihard; brittle; easily frangible; does not soil.

Specific gravity 8·000.

Melts easily before the blowpipe.

Its constituents, as determined by John, are

		Atoms.	
Protoxide of lead,	87·382	6·24	4·5
Carbonic acid,	3·846	1·39	1
Oxide of iron and lime,	0·481		
Copper,	trace,		
Ferruginous silica,	2·404		
	94·113		

If any confidence can be put in this analysis, the mineral is a mixture or compound of

3½ atoms protoxide of lead,
1 atom carbonate of lead.

But the deficiency of six per cent. in the analysis, renders it doubtful whether the carbonic acid may not have been in combination with an alkaline substance not detected.

Sp. 3. *Sesquioxide of Lead.*

Native minium.

This species was discovered by Mr. Smithson in Germany, disseminated in small quantity in a compact carbonate of zinc. In general it was in a pulverulent state, but in some places showed under the microscope a flaky and crystalline texture.

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[*] Schweigger's Jahrbuch, ii. 109.

[†] Leonhard's Jahrbuch der Mineralogie und Geognosie, iii. 202.

According to M. Kapper, the shape of the crystal is a right oblique prism, with a rhombic base, the angles of which are 9 3 44′ and 86° 16′.*

The colour is the same as that of factitious minium, a vivid red, mixed with yellow. Mr. Smithson ascertained that it possesses the chemical properties of sesquioxide of lead.

According to him it is produced by the decay of galena, which he suspects to be itself a secondary production from the metallization of white carbonate of lead by sulphuretted hydrogen.†

Sp. 4. *Sulphuret of Lead.*

Galena, bleiglanz, blaubleierz.

This is by far the most abundant ore of lead. From it almost all the lead of commerce is extracted. It occurs both in beds and veins in primary and secondary rocks. In Cornwall veins of it pass through primary rocks. The rich mines of lead in the north of England consist chiefly of veins traversing the coal formation. At Leadhills and Wanlockhead the veins traverse transition rocks. At Strontian the vein lies between gneiss and granite. This ore is more abundantly scattered over the surface of the earth than any other. Few countries exist which are altogether destitute of it.

Colbur pure lead-grey; apt to tarnish, and the iridescent colours appear in preference on the secondary faces; streak unaltered.

Occurs massive, and then is usually granular or fibrous; but it is very frequently crystallized, and then is foliated with a three-fold cleavage. Primary form a cube. Occurs also in regular octahedrons, and in the form of the leucite crystal, in consequence of the angles of the cube being replaced by three faces, which, increasing in size, obliterate the original faces of the cube. On the faces of the octahedron low three-sided pyramids are sometimes observed, converting the octahedron into an icosatetrahedron.

Lustre metallic, splendent.

Rather sectile.

Hardness 3; specific gravity from 7·532 to 7·652.

Before the blowpipe melts, and if heated with precaution on charcoal, yields globules of lead after the sulphur is burnt off.

When pure, its constituents are

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* Ann. des *Mines* (2d series), v. 325.

† Nicholson's Jour. xvi. 127.

		Atoms.
Sulphur,	13·34	2
Lead,	86·66	13
	100·00	

When the structure is fibrous the lustre is less, and the mineral contains antimony, but whether in atomic proportions has not been ascertained.

Sp. 5. *Supersulphuret of Lead.*

This mineral is not uncommon in the north of England. The specimen which I subjected to analysis was from Ireland, but I do not know the locality.

Colour blue; lustre metallic.

Texture fine granular; massive; opaque.

Hardness 3; specific gravity 6·713.

Before the blowpipe on charcoal burns with a blue flame, then decrepitates, then melts, and finally leaves a globule of pure lead.

When 100 parts of this mineral are heated in a glass tube, 1·79 parts of sulphur sublime, and common galena remains. Hence the composition is

		Atoms.	
Galena,	98·21	6·547	7·31
Sulphur,	1·79	0·895	1
	100·00		

So that the composition is

7 atoms sulphuret of lead,
1 atom sulphur;
Or 7 atoms lead,
8 atoms sulphur.

Sp. 6. *Seleniet of Lead.*

This mineral was discovered in 1823, by M. Zinken, in the eastern part of the Hartz, in two places not far from each other, near Zorge, where it occurs in veins of iron, traversing clay slate and greenstone, disseminated in a magnesian limestone, and near Tilzerode, where the seleniet is more abundant, and disseminated in like manner in magnesian limestone. It was analyzed and imperfectly described by M. H. Rose.*

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* Ann. de Chim. et de Phys. xxix. 116.

It has so great a resemblance to fine grained sulphuret of lead, that we can scarcely distinguish the one from the other.

Colour lead-grey; lustre metallic.

Structure granular. When the grains are large, a foliated structure may be observed in them.

Opaque; rather sectile.

Hardness 3; specific gravity 7·187.

Does not sublime, nor melt when heated in a glass tube. When the tube is open at both ends a little selenium sublimes, and crystals of selenic acid are formed, which deliquesce. The assay is surrounded with fused protoxide of lead, and the apartment is filled with the peculiar odour of selenium.

On charcoal it smokes and burns with a blue flame before the blowpipe. The assay is surrounded with oxide of lead, but no metallic lead is obtained unless we mix the assay with carbonate of soda. With fluxes the presence of lead only is detected.

Its constituents, by the analysis of Rose, are

		Atoms.
Selenium,	27·59	5·52
Lead,	71·81	5·52
	99·40	

Obviously 1 atom selenium,
1 atom lead.

So that it is a simple seleniet of lead.

Seleniet of lead is found in the same place mixed or combined with some other seleniets.

1. Combined with seleniet of cobalt, it closely resembles the pure ore. It was composed of

		Atoms.	
Selenium,	31·42	6·28	6·54
Lead,	63·92	4·91	5·11
Cobalt,	3·14	0·96	1
Iron,	0·45	0·12	0·12
	98·93		

These numbers approach (including the iron with the cobalt)

5 atoms seleniet of lead,
1 atom seleniet of cobalt.

2. Combined with seleniet of copper. This variety also bears a close resemblance to pure seleniet of lead.

Its constituents were

		Atoms.	
Selenium,	29·96	5·99	6·11
Iron with trace of lead,	0·44	0·12	—
Lead,	59·67	4·59	4·69
Iron,	0·33	0·09	—
Copper,	7·86	1·96	2
Undecomposed,	1·00		
	99·26		

These numbers approach nearly to
9 atoms seleniet of lead,
4 atoms seleniet of copper.

3. Another compound of seleniets of copper and lead had a violet colour, and was more fusible than the last variety. Its constituents were

		Atoms.
Selenium,	34·26	6·85
Lead,	47·43	3·65
Copper,	15·45	3·86
Silver,	1·29	0·09
Oxides of lead and iron,	2·08	
	100·51	

These numbers indicate a compound of
1 atom seleniet of lead,
1 atom seleniet of copper.

4. Seleniet of lead occurs also mixed with seleniet of mercury in various proportions, without much affecting its external characters. Two specimens, analyzed by Rose, gave the following constituents:—

			Atoms.			
		2	1	2	1	2
Selenium,	24·97	27·98	4·99	5·59	3·53	2·66
Lead,	55·84	27·33	4·29	2·10	3·04	1
Mercury,	16·94	44·69	1·41	3·72	1	1·77
	97·75	100·00				

The first seems to be composed of
3 atoms seleniet of lead,
1 atom sesquiseleniet of mercury.

The second of

4 atoms seleniet of lead,
7 atoms seleniet of mercury.

Sp. 7. *Bitelluret of Lead.*

Foliated ore of tellurium, black tellurium, tellurium glance, nagyaker erz.

This mineral has been hitherto found only in veins at Nagyag and Offenbanya, in Transylvania. It is now very rare.

Colour blackish lead-grey; streak similar.

Massive and crystallized in very small tables. The primary form appears to be a right square prism. The terminal edges and angles of the prism being replaced by faces, convert it into a table terminated by eight double faces.

Foliated; lustre metallic; opaque.

Highly flexible when in thin laminæ; very sectile.

Hardness 1 to 1·5; specific gravity 7·085.

Before the blowpipe it melts easily upon charcoal, and gives a malleable metallic button. With borax it gives a bead of gold containing a little silver. Dissolves easily in nitric acid.

Its constituents are

	*	†	Mean.	Atoms.
Tellurium, .	32·2	31·96	32·08	8·02
Lead, . .	54·0	55·49	54·74	4·21
Gold, . .	9·0	8·44	8·72	0·72
Silver, . .	0·5	trace	—	—
Copper, . .	1·3	1·14	1·22	0·30
Sulphur, . .	3·0	3·07	3·03	1·51
	100	100·10		

If we admit all the constituents, except the tellurium and lead, to be accidental impurities, it is evident that the mineral is a compound of

2 atoms tellurium,
1 atom lead;

Or it is a bitelluret of lead.

M. G. Rose has described a bitelluret of lead from Altai,[‡] which seems to be this species in a state of greater purity than it had been previously observed to be.

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[*] Klaproth, Beitrage, iii. 32. [†] Brandes, Schweigger's Jahrbuch, v. 409.

[‡] *Poggendorf's Annalen*, xviii. 68.

Colour tin-white, very similar in appearance to that of native antimony.

Sectile; easily reducible to a fine powder: specific gravity 8·159.

Before the blowpipe on charcoal it gives a blue tinge to the flame. In the reducing flame melts into a bead, which becomes smaller and smaller, and at last leaves nothing but a little silver. Round the assay is formed a metallic shining ring of telluret of lead; at a little farther distance a brownish yellow matter, which tinges flame blue, and is easily dissipated by heat.

Its constituents were

		atoms
Silver,	1·28	0·09
Lead,	60·85	4·69
Tellurium,	38·37	9·6
	100·50	

If we include the silver with the lead, it is obvious that the mineral is composed of

2 atoms tellurium,
1 atom lead.

It is therefore a bitelluret of lead, obviously in a state of much greater purity than the Nagyag bitelluret.

Sp. 8. *Chloride of Lead.**

Cotunnia of Monticelli, cotunnite of Von Kobell.

This mineral was observed by Monticelli and Covelli in the crater of Mount Vesuvius, after the eruption of 1822. It was accompanied by common salt, chloride and sulphate of copper, and other salts, and was named in honour of one of the medical men of Naples.

Colour white. In acicular crystals.

Is slightly scratched by the nail.

Lustre adamantine, inclining occasionally to silky or pearly.

Specific gravity 1·897.

Fuses very easily before the blowpipe, colouring the flame blue, and emitting a white smoke which is condensed on the charcoal. With carbonate of soda it yields globules of lead.

It dissolves in about 27 times its weight of cold water.

Its constituents, according to the analysis of Berzelius, are

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* Allan's Manual, p. 34.

		Atoms.
Chlorine,	25·48	5·66
Lead,	74·52	5·7
	100·00	

It is obviously a simple chloride of lead.

Sp. 9. *Dichloride of Lead.*

Berzelite.

This rare mineral has been found in the Mendip hills, in Somersetshire. It is there found in crystalline masses, having a fibrous and radiated structure disposed on earthy black ore of manganese.

Colour white, with a yellowish or reddish tinge.

Cleavage highly perfect, and easily obtained parallel to the faces of a four-sided prism of 102° 27′.

Lustre pearly on the cleavage faces.

Hardness 2·5 to 3; specific gravity 7·0 to 7·1.

Decrepitates slightly before the blowpipe, and is easily fused, the globule presenting a deeper yellow than the mineral. On charcoal it is reduced, and emits fumes of muriatic acid. Treated with peroxide of copper and biphosphate of soda, the flame assumes an intense blue colour.

Its constituents, according to the analysis of Berzelius, are

		Atoms.
Lead,	83·2	6·4
Chlorine,	13·77	3·2
Carbonic acid,	1·03	
Silica,	1·46	
Water,	0·54	
	100·00	

It is obviously a compound of 2 atoms lead and 1 atom chlorine, or it is a dichloride of lead.*

2. *Simple Oxygen Salts.*

Sp. 1. *Carbonate of Lead.*

White lead ore. Black lead ore.†

This species, next to galena, is the most abundant of all the ores of lead. It occurs in veins and beds in almost every formation, and usually accompanies galena. Beautifully crystallized specimens are found in Saxony, and at Leadhills and Wanlockhead, in Scotland.

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* Allan's Manual, p. 59.

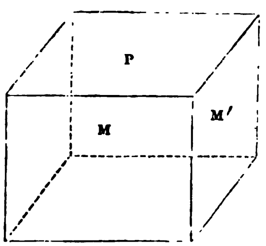
† The black lead ore of Werner is a mixture of carbonate of lead and galena.

Colour white, passing into yellowish grey, smoke grey, or even into greyish black. Sometimes tinged green or blue by copper; streak white.

Massive, granular, or even in powder. The primary form obtained by cleavage is a right rhombic prism.

Mon M' 117° 18'

It occurs in tabular crystals, in six-sided prisms, in triangular dodecahedrons, and in elongated octahedrons.



The crystals have a foliated texture, and cleave parallel to the faces of the primary form, and in the direction of the shorter diagonal of the base of the prism. Cross fracture small conchoidal, or sometimes small grained, uneven.

Lustre adamantine, passing into resinous; sometimes pearly.

Transparent to translucent; rather brittle.

Hardness 3·25; specific gravity from 6·465 to 6·480.

Before the blowpipe it decrepitates, and changes its colour into yellow and red. If properly managed it yields a globule of metallic lead. Reduced to powder and thrown on ignited charcoal it yields a phosphorescent light.

Effervesces in dilute nitric acid, and is easily soluble.

Its constituents, when pure, are

Carbonic acid,	16·418	. 2·75
Protoxide of lead,	83·582	. 14
	100·000	

Or it is a simple carbonate of lead. I analyzed a pure crystallized specimen, and found the constituents,

		Atoms.
Carbonic acid,	16·406	. 5·966
Protoxide of lead,	8·534	. 5·966
Water, .	0·060	
	100·000	

Sp. 2. *Sulphate of Lead.*

Prismatic lead spar—lead vitriol.

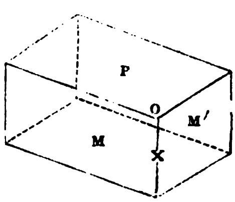
This species is much less abundant than the preceding. It is found in lead and copper veins traversing clay slate and greywacke slate, particularly in the upper parts. Fine specimens occur at Leadhills and Wanlockhead, in Parys mine, and at Mellanoweth, in Cornwall. It is found also in Germany, Spain, Siberia, and the United States of America.

Colour yellowish, greyish or greenish white, and also yellowish and smoke grey; sometimes tinged faintly green and blue; streak white.

Massive, but often also crystallized in the form of rhombic prisms with dihedral summits. But when the prism is short, the prism assumes the aspect of an octahedron. The structure is foliated, and admits of mechanical division parallel to the faces of a right rhombic prism.

M on M′ 103° 42′

which is its primary form.



The secondary forms are produced by replacing the angle O, the edge X, and terminal edges of the prism by planes, which sometimes increase so much in size as to obliterate nearly the original faces of the prism.

Lustre adamantine, inclining to vitreous or resinous.

Transparent to translucent; brittle.

Hardness 2·75; specific gravity from 6·259 to 6·298.

Decrepitates in the flame of a candle, and frequently assumes a slightly reddish tinge on the surface. In powder it fuses before the blowpipe into a white slag, which is reduced into metallic lead by the addition of carbonate of soda.

The constituents of this species are as follows:—

	*	*	†	‡	Atoms.
Sulphuric acid,	24·8	25·75	26·0191	25·655	5·13
Protoxide of lead,	71·0	70·50	72·9146	74·045	5·28
Protoxide of iron,	1·0	—	0·1151	—	
Prot. of manganese,	—	—	0·1654	—	
Water, .	2·0	2·25	0·1242	0·300	
	98·8	98·50	99·3384	100·000	

* Klaproth, Beitrage, iii. 162. † Stromeyer, Hoffmann's Handbuch, iv. 1, 43.

‡ By my analysis. The specimen was a colourless crystal from Leadhills, apparently pure.

It is obviously a compound of

1 atom sulphuric acid,
1 atom protoxide of lead.

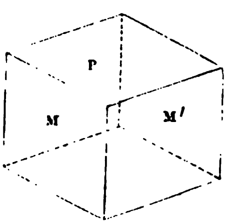
And therefore a simple sulphate of lead.

Sp. 3. *Chromate of Lead.*

Red lead ore.

This mineral was first found in the mines of Beresof, near Ekateringberg, in Siberia, in a vein traversing gneiss and mica slate. It is now very scarce in this first locality, but has been more recently found in Sabara, or Villa Rica, in Brazil.

Colour various shades of hyacinth red; streak orange yellow.



Occurs both massive and crystallized. The primary form is an oblique rhombic prism.

M on M′ 93° 30′
P on M or M′ 99° 10′

For the fullest account of the secondary forms of this mineral, the reader is referred to M. Soret, who has given a description and figure of each modification. See *Annales des Mines*, iii. 479, and v. 281.

Structure foliated; cross fracture uneven, or small conchoidal.

Lustre adamantine.

Translucent, sometimes only on the edges; sectile.

Hardness 2·75; specific gravity, by my trial, 6·000.

Before the blowpipe it becomes black, and decrepitates if quickly heated. It may be melted, however, into a shining slag, containing globules of metallic lead. Gives a green colour to borax.

Dissolves without effervescence in nitric acid, solution yellow.

When pure, the constituents of this mineral are

		Atoms.
Chromic acid,	31·71	4·88
Protoxide of lead,	68·29	4·88
	100·00	

Or,

1 atom chromic acid,
1 atom protoxide of lead.

It is therefore a simple chromate of lead.

Sp. 4. *Melanochroite.*

Subsesquichromate of lead.

This mineral occurs in veins in a limestone rock at Beresofsk, in the Ural, along with chromate of lead, vauquelinite, phosphate of lead, a galena and quartz. It was first described, named and analyzed, by M. Hermann.*

Colour between cochineal red and hyacinth red; by exposure to the air it becomes lemon yellow; powder tile red.

Massive; but more commonly crystallized in rhombic prisms with two of the opposite faces much larger than the others, giving the crystal the aspect of a table. The crystals are small, and interwoven together like a net.

Lustre resinous, glimmering.

Translucent on the edges, almost opaque.

Very soft; slightly brittle; easily reduced to powder.

Specific gravity 5·75.

When heated it hardly gives out a trace of water. Its colour becomes darker, but resumes its original appearance when the mineral cools.

Before the blowpipe on charcoal, it cracks but does not fly off. It then fuses readily into a dark mass, which on cooling assumes a crystallized appearance. In the reducing flame lead is sublimed, and oxide of chromium and grains of lead are left on the charcoal. Fused with the fluxes it gives a green coloured bead.

Its constituents are

			Atoms.
Chromic acid,	23·31	3·58	1
Protoxide of lead,	76·69	5·47	1·52
	100·00		

These numbers correspond with

1 atom chromic acid,
1½ atom protoxide of lead.

It is therefore a subsesquichromate of lead.

Sp. 5. *Tungstate of Lead.*

This mineral occurs at Zinnwald, in Saxony, and was first subjected to a chemical examination by Breithaupt and Lampadius.

Colour yellowish grey.

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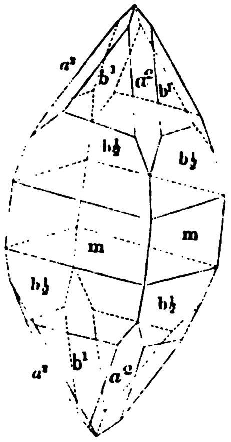
* *Poggendorf's* Annalen, xxviii. 162.

Usually crystallized, and the primary form appears to be an octahedron with a square base. The figure in the margin was given by Mr. Levy, as representing a crystal in possession of Mr. Turner.* The following are his measurements :

b^1 on b^1	99°	43′
a on a^2	106	47
$b_{\frac{1}{2}}$ on $b_{\frac{1}{2}}$	92	46
b^1 on b^1	131	30
a^2 on a^2	65	
$b_{\frac{1}{2}}$ on $b_{\frac{1}{2}}$	154	36
m on b^1	155	45
m on a^2	126	37
m on $b_{\frac{1}{2}}$	167	

In some crystals the planes $b_{\frac{1}{2}}$ are wanting, while others are composed of this modification alone. The crystals of this mineral bear a striking analogy to, or almost agree with those of molybdate lead.



Lustre resinous; faintly translucent.

Hardness 3; specific gravity 8·000.

Before the blowpipe it melts and gives out vapours of lead, leaving a crystalline globule of a dark colour and metallic aspect, which yields a pale grey powder. When the lead has been driven off, the assay yields with borax a yellow globule, transparent, and becoming dark red on cooling; and with biphosphate of soda, at a certain saturation, in the reducing flame, a blue globule.

I am not aware that this mineral has been regularly analyzed. From Berzelius' formula, it would seem to be a tungstate of lead, composed of

1 atom tungstic acid, .	15·5
1 atom protoxide of lead, .	14
	29·5

Sp. 6. *Molybdate of Lead.*

Yellow lead ore.

This species was first noticed by Jacquin in 1781. It occurs in many of the lead mines of Carinthia, and likewise in limestone at Annaberg in Austria. It has been observed also in Upper Hungary, in Pennsylvania and Massachusetts, at Zimapan in Mexico, and also at Mendip in Somersetshire.

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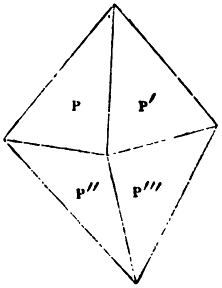
* Annals of Philosophy (2d series), xii. 364.

Colour wax-yellow, passing into siskin green and olive green; also into orange-yellow, yellowish-grey, and greyish-white; streak white.

Massive and crystallized. The primary form is an octahedron with a square base.
P on P′ 99° 46′
P on P″ 131° 15′



It occurs crystallized in flattish and acute octahedrons, variously modified, in crystals approaching to cubes, in tables, and in four, six, and eight-sided prisms, terminated by four-sided pyramids.

Structure lamellar; cleaves parallel to the faces of the primary form. Fracture imperfect conchoidal.

Semitransparent to translucent on the edges; brittle.

Hardness 2·75; specific gravity, according to Hatchett, 5·706. Haidinger states it 6·760.

Before the blowpipe it decrepitates briskly and assumes a darker colour, which, however, again disappears.

Alone upon charcoal, it melts and is absorbed by it, leaving behind some reduced globules of metallic lead. With borax, in the exterior flame, fuses readily into an almost colourless glass. In the interior flame we obtain a transparent glass, which, on cooling, becomes all at once dark and opaque. With biphosphate of soda fuses readily. When the proportion of molybdate of lead is small, the glass is green; when the quantity is greater, the glass is black and opaque. Fuses with carbonate of soda; a portion of the mass is absorbed by the charcoal, and reduced lead remains.

The constituents of this mineral are

	*	†	‡	Atoms.
Molybdic acid, .	34·25	37·00	40·5	4·11
Protoxide of lead,	64·42	58·40	58·0	4·17
Oxide of iron, .	—	3·08		
Silica, . . .	—	0·28		
	98·67	98·76	98·5	

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* *Klaproth, Beitrage*, ii. 275. † Hatchett, Phil. Trans. 1796, p. 323.
‡ *Göbel. Schweigger's* Jahrbuch, vii. 71. I have corrected his estimate *of oxide of lead from the chloride.*

The atomic numbers, deduced from Hatchett's analysis, show evidently that the mineral is composed of

1 atom molybdic acid,
1 atom protoxide of lead.

Or it is a simple molybdate of lead.

Sp. 7. *Trismolybdate of Lead.*

This mineral was first noticed by M. Boussingault, who observed it in the Paramo-Rica, near Pamplona in South America. He has published an imperfect description and analysis of it.*

It occurs in small concretions. Its colour is greenish-yellow, and its specific gravity 6·00.

Before the blowpipe on charcoal it melts easily into a globule of a dark colour; when a little carbonate of soda is added we easily obtain a button of reduced lead; while, at the same time, an infusible scoria is formed. When a new dose of soda is added, the scoria is imbibed into the charcoal, and by grinding and washing, a grey metallic powder is obtained, having the aspect of molybdenum.

Its constituents, by Boussingault's analysis, are

		Atoms.
Protoxide of lead,	73·8	5·27
Molybdic acid,	10·0	1·11
Carbonic acid,	2·9	1·05
Muriatic acid,	1·3	0·28
Phosphoric acid,	1·3	0·28
Chromic acid,	1·2	0·18
Oxide of iron,	1·7	0·34
Alumina,	2·2	0·97
Quartz,	3·7	
	98·1	

If we suppose all the acids to have been in combination with oxide of lead. It is obvious that as the other acids amount to 1·79 atoms, 1·79 atoms must be subtracted from the oxide of lead. There remain 3·48 to unite with 1·11 atoms of molybdic acid. This is very nearly

3 atoms protoxide of lead,
1 atom molybdic acid.

The mineral therefore must be a trismolybdate of lead.

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* Ann. de Chim. et de Phys. xlv. 325.

3. *Double Oxygen Salts.*

Sp. 1. *Oxido-Chloride of Lead.*

Hitherto this mineral has been observed only in a single specimen in possession of the Stockholm Academy, which was analyzed and described by Berzelius.* It was ticketed *lead spar*, from Mendip, near Churchill in Somersetshire. It was chiefly carbonate of lead, but it contained two portions of a yellower colour than the rest, which attracted the peculiar attention of Berzelius. One of these being examined by the blowpipe, proved to be molybdate of lead. The other portion constituted the present species.

Colour straw-yellow.

Easily frangible, and cleaves with a foliated texture. The cleavage planes meet under an angle of between 102° and 103°.

Before the blowpipe it decrepitates slightly, and is easily melted. The fused globule, when cold, has a deeper yellow colour than the original mineral. On charcoal it is reduced to metallic lead, and at the same time emits fumes of muriatic acid.

Dilute nitric acid dissolves it with slight effervescence, and if several fragments, taken from different parts of the specimen, be thrown into the acid at once, the effervescence occasioned by them may be observed to be different.

The constituents of this mineral are

		Atoms.
Chlorine,	8·45	1·87
Carbonic acid,	1·03	0·03
Lead,	83·667	6·43
Silica,	1·46	
Water,	0·54	
	95·147	

The carbonic acid was owing to the admixture of carbonate of lead; subtracting 0·03 atom of lead for this, there remain 6·4 atoms, 1·87 of which must have been in combination with chlorine, constituting chloride of lead. There remain 4·53 atoms of lead, which in the mineral must have been in the state of protoxide, as was the case also with the lead combined with the carbonic acid. But 4·56 atoms of lead require 4·56 oxygen to convert them to protoxide. Adding this to the 95·147 obtained by analysis, it raises the amount to 99·707.

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* Kong. Vet. Acad. Handl., 1823, p. 184.

The mineral then is a compound of
1·87 atoms chloride of lead,
4·53 atoms oxide of lead.

These numbers approach
3 atoms chloride } of lead.
7 atoms protoxide }

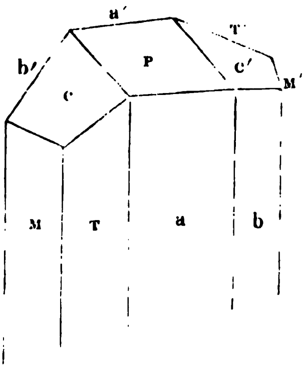
Sp. 2. *Cupreous Sulphate of Lead.*

This mineral has hitherto been found only at Leadhills. It was first analyzed and described by Mr. Brooke.* Sowerby had noticed it in his British Mineralogy (Vol. 3d, p. 5,) under the name of *blue carbonate of copper.*

The colour resembles that of the brightest specimens of blue carbonate of copper.

Found only in crystals similar to the figure in the margin. It cleaves easily parallel to the faces M and T.

M on T 102° 45′



Hence the primary form is probably a right oblique prism, with the above angle.

The following are Mr. Brooke's measurements of the inclination of the faces:

M on b′	104°	50′
c	120	30
P	90	
T on a	161	30
M′ on b	104	50
T′	102	45
P on a or a′	90	

Hardness 3; specific gravity, as determined by Mr. Brooke, 5·3, but the specimen was not quite free from carbonate of lead and cupreous sulphato-carbonate of lead.

Its constituents, as determined by Brooke, are

		Atoms.	
Sulphate of lead,	75·4	3·94	1·09
Oxide of copper,	18·0	3·6	1
Moisture,	4·7	4·17	1·15
	98·1		

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* Annals of Philosophy (second series), iv. 117.

These numbers approach nearly to

1 atom sulphate of lead,
1 atom oxide of copper,
1 atom water.

The water and oxide of copper (as is evident from the colour of the mineral) are united together, constituting hydrate of copper. Hence the constitution of the mineral is

1 atom hydrate of copper,
1 atom sulphate of lead.

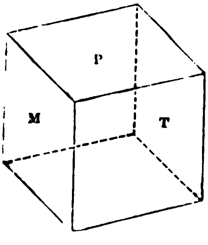
Sp. 3. *Sulphato-Carbonate of Lead.*

This mineral has hitherto been found only at Leadhills. It was first noticed by Bournon, as a variety of carbonate of lead. Mr. Brooke analyzed it, and published a description of it in 1820.*

Colour greenish-white or yellowish-white, sometimes inclining to grey; streak white.

The crystals are usually oblique-angled four-sided prisms, with curved faces terminated by two planes, set obliquely on the obtuse edges of the prism, but producing a horizontal edge with each other. They admit of cleavage very readily, parallel to a plane which replaces obliquely their acute lateral edges. There are two less perfect cleavages intersecting the former, at angles of 120° 45′, (according to Brooke,) and 88° 45′, (according to Haidinger). We may therefore consider the primary form as a doubly oblique prism.

M on T 120° 45′
P on M 88 45



The laminæ resulting from cleavage are flexible.

Lustre adamantine, inclining to resinous, pearly upon the perfect cleavage surface.

Translucent; sectile.

Hardness 2 to 2·5; specific gravity, as determined by Brooke, 6·8 to 7·0.

Effervesces very slightly when put into nitric acid, and leaves a quantity of sulphate of lead undissolved.

Its constituents, as determined by Brooke, are as follows:

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* Edin. Phil. Jour. iii. 117.

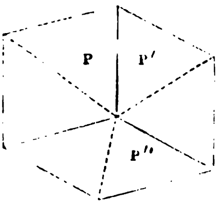
		Atoms.
Carbonate of lead,	46·9	. 2·8
Sulphate of lead,	53·1	. 2·8
	100	

These numbers obviously correspond with
1 atom carbonate of lead,
1 atom sulphate of lead,
which, of course, constitute the component parts of this mineral.

Sp. 4. *Sulphato-Tricarbonate of Lead.*

This species, which has been met with only at Leadhills, had been noticed by Bournon, under the name of *rhomboidal carbonate of lead.* He says that it dissolves more readily in nitric acid, and with a greater effervescence than common carbonate of lead. It was first analyzed and described by Mr. Brooke.*

It occurs both in rhomboids and in prismatic crystals. The colour of the rhomboids is pale greenish, or yellowish or brownish, but when very minute they are colourless and transparent. The prismatic varieties are colourless, or of various shades of pale yellow.



The primary form of the crystal is considered to be an acute rhomboid.

P on P′ 72° 30′

Of course the supplementary angle is 107° 30′.

The six-sided prism is produced by faces replacing all the lateral angles of the rhomboid. It is also subject to modifications, producing three or four varieties of more obtuse rhomboids.

The natural planes, except in very minute crystals, are more or less rounded.

Hardness 2·5; specific gravity, as determined by Brooke, from 6·3 to 6·5.

Its constituents are as follows:

	*	†	Mean.	Atoms.	
Carbonate of lime,	72·5	72·7	72·6	4·33	3
Sulphate of lead, .	27·5	27·3	27·4	1·44	1
	100	100			

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* Edin. Phil. Jour. iii. 118.
† Brooke, ibid.
‡ Stromeyer, Annals of Philosophy (second series), x. 232.

The constitution is obviously

3 atoms carbonate of lead,
1 atom sulphate of lead.

Hence the reason of the name given to this mineral by Mr. Brooke.

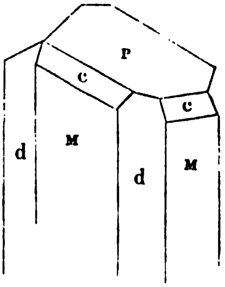
Sp. 5. *Chloro-Carbonate of Lead.*

Mureo-carbonate of lead—corneous lead.

This rare mineral has been met with at Hausbaden, near Badenweiler in Germany; in Cromford level near Matlock, Derbyshire; at Southampton, Massachusetts, and I have a specimen from Alston Moor, in Cumberland.

Colour white, and pale tints of grey, yellow and green; also bright yellow; streak white.

It has been observed only in crystals. The primary figure is a rectangular square prism. The figure in the margin is that of a crystal in the British Museum.



M on M 90°
M on d 135

Lustre adamantine.

Transparent to translucent; rather sectile.

Hardness 2·75; specific gravity, as determined by Chenevix, 6·056.

It was analyzed by Klaproth and Chenevix with nearly the same result. Klaproth's analysis,* when corrected by the application of the atomic numbers, is

		Atoms.
Chlorine, .	13·56	3·01
Carbonic acid,	8·51	3·09
Lead, .	39·17	3·01
Protoxide of lead,	43·32	3·09
	104·56	

The excess is owing to a slight overrating of the oxide of lead, and consequently also of the carbonic acid. If we allow for this excess, it is obvious that the constitution of the mineral is

1 atom chloride of lead,
1 atom carbonate of lead.

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* Beitrage, iii. 141.

Sp. 6. *Phosphate of Lead.*

Polychrome, pyromorphite, traublenblei, brown lead ore, green lead.

This mineral occurs chiefly in veins, and accompanies the other ores of lead. Fine specimens of it occur at Leadhills and Wanlockhead, at Poullaouen and Huel Goet, in Brittany, at Zschopau and other places in Saxony, in the Hartz, Bohemia and Hungary.

Colour generally green, yellow or brown, each of several shades. The fine orange-yellow crystals found at Leadhills, contain chromate of lead, to which they owe their colour; streak white, sometimes inclining to yellow.

Occurs massive, and frequently crystallized in regular six-sided prisms. The prisms not unfrequently terminate in six-sided pyramids; and the edges of the prism are often replaced by tangent planes. The angle which the lateral face of the prism makes with the corresponding face of the pyramid is 131° 45′.

Fracture imperfect conchoidal, uneven.

From semitransparent to translucent on the edges.

Lustre resinous; brittle.

Hardness 2·75; specific gravity, by my trials, varies from 6·5781 to 6·915.

Before the blowpipe it melts by itself upon charcoal, and the bead on cooling assumes a polyhedral form and a dark colour. In the reducing flame the globule becomes bluish. At the moment of crystallization it becomes luminous, and the faces become larger.

It dissolves without difficulty in hot nitric acid.

We have numerous analyses of this mineral, which it will be proper to state, that the reader may be able to judge accurately of its constitution.

Klaproth[*] analyzed four specimens, and obtained the following results:

Protoxide of lead, .	78·58	78·40	77·1	80
Phosphoric acid, .	19·73	18·37	19·0	18
Muriatic acid, . .	1·65	1·70	1·54	1·62
Peroxide of iron, .	—	0·10	0·1	—
	99·96	98·57	97·74	99·62

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[*] Beitrage, iii. 146. The first specimen was brown phosphate from Huel Goet; the second, siskin green phosphate from Zschopau; the third, grass-green phosphate from Hoffsgrund; the fourth was yellow phosphate from Wanlockhead, having a specific gravity of 6·560.

M. Charles Kersten, of Freyberg, analyzed a number of brown coloured phosphates of lead from various localities.* The following are the results which he obtained:

	1 †	2 ‡	3 §	4 ‖	5 ¶	6 **	7 ††
Protox. of lead,	72·17	75·830	81·330	81·460	82·083	82·301	82·290
Lime, . .	6·47	3·711	0·430	0·320	0·320	—	—
Chlorine, .	2·00	2·110	1·909	1·956	1·990	1·989	1·989
Phos. acid with some fluor. acid,	19·36	18·249	16·331	16·264	15·607	15·710	15·721
	100	100	100	100	100	100	100

The following table exhibits the atomic proportions deduced from these analyses:

	Atoms.						
	1	2	3	4	5	6	7
Protox. of lead,	5·15	5·41	5·80	5·81	5·86	5·88	5·88
Lime, . . .	1·83	1·06	0·12	0·09	0·09	—	—
Chlorine, . .	0·44	0·47	0·42	0·43	0·44	0·44	0·44
Phosphoric acid,	4·3	4·07	3·63	3·61	3·46	3·49	3·49

It is obvious that there is a slight error in the estimate of the phosphoric acid. It was determined by deducting the other constituents from the quantity analyzed, and considering the deficiency as phosphoric acid. But a portion of the lead in the mineral was in the metallic state, being combined with chlorine. This quantity was about 0·44 atom, or 6·16 grains of protoxide, equivalent to 5·72 grains of metallic lead. The difference 0·44 ought to have been added to the phosphoric acid.

If we examine the first of Kersten's analyses, we shall find the polysphærite consisted of

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* Ann. de Chim. et de Phys. xlviii. 157.

† The polysphærite of Breithaupt. Found in the mine Sonnenwirbel, near Freyberg, in small spheres of a brown colour, and a specific gravity of 6·092.

‡ From Mies, in Bohemia. In small brown sphericles, having a specific gravity of 6·444.

§ Also from Mies, crystallized, and having a specific gravity of 6·983.

‖ From Bleystadt, in Bohemia. Colour brown, in fine crystals; specific gravity 7·009.

¶ From England, in small brown coloured crystals.

** From Poullaouen, in brown coloured six-sided prisms; specific gravity 7·048.

†† Also from Poullaouen, but amorphous. Specific gravity 7·050.

0·44 atom chloride of lead,
4·71 atom oxide of lead,
1·83 lime,
6·54 atoms of bases,
4·3 atoms phosphoric acid.

Now 6·54 is to 4·3 almost exactly as 1·5 to 1. The mineral then is composed (abstracting the chloride) of subsesquiphosphates. The constitution seems to be

1 atom chloride of lead,
4 atoms subsesquiphosphate of lime,
11 atoms subsesquiphosphate of lead.

A similar analysis of the other analyses would lead to the same result. For example, the 6th analysis shows us that the Poullaouen phosphate consists of

0·44 atom chloride of lead,
5·44 atoms oxide of lead,
3·49 atoms phosphoric acid.

5·44 is to 3·49 as 1·55 to 1. Hence the mineral is obviously composed of

1 atom chloride of lead,
8 atoms subsesquiphosphate of lead.

The variation in the quantity of lime shows that it is not chemically combined. But as apatite and phosphate of lead have the same crystalline form, we need not be surprised that one should be occasionally substituted for the other.

The following table shows the result of several analyses of this mineral, made partly by myself and partly by Mr. Blythe, in my laboratory. I have added an analysis of Wöhler, and another of Berthier, to the table.

	*	†	‡	§	‖	¶	**
Chlorine, . .	2·81	2·724	2·7	2·656	2·521	2·56	1·61
Lead, . . .	8·11	7·860	7·8	7·668	7·254	7·39	—
Phosphoric acid, .	17·93	17·400	16·85	17·600	17·200	16·01	16·93
Protoxide of lead, .	70·01	66·633	70·427	69·639	72·665	74·04	79·44
Protoxide of iron, .	0·90	1·76	1·100	2·008	0·720	—	1·82
Silica, . . .	—	—	—	—	0·040	—	—
Moisture, . .	1·00	2·00	1·000	0·800	0·400	—	—
	100·76	98·336	99·805	100·365	100·791	100·00	100

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* The specimen was from Wicklow, light grass-green, in six-sided prisms. Specific gravity 6·6509.

† From Leadhills, quite similar to the preceding. Specific gravity 6·5781.

‡ From Leadhills, yellow, in six-sided prisms. Specific gravity 6·70016.

§ From Leadhills, olive green, massive, but exhibiting imperfect six-sided prisms. Specific gravity 6·631.

‖ From Poullaouen, brown, in large six-sided prisms. Sp. gr. 6·915.

¶ Wöhler, Poggendorf's Annalen, iv. 162.

** Berthier, Ann. des Mines, vii. 152. The specimen was from Chenelette. No description is given.

It is obvious enough that these analyses lead to the same conclusion. All the phosphates of lead are composed of chloride of lead, and subsesquiphosphate of lead united together in various proportions. But usually between 1 atom chloride and 6 to 8 sesquiphosphate of lead.

Sp. 7. *Vanadiate of Lead.*

This mineral was first observed at Zimapan, in Mexico, and an analysis of it was made by M. Del Rio, in 1804, who announced the existence of a new metal in it; but the analysis being repeated by Collet Descotils, in 1805, he assured the public that the supposed new metal was nothing but chromic acid. Some years ago Mr. Johnston observed the same mineral at Wanlockhead; and I have specimens which I received from Mr. Doran, an Irish mineral dealer, who assured me that he picked them up in an old abandoned lead mine in the County of Wicklow, in Ireland.

Colour light brownish-yellow.

Streak white.

Usually in small spheres, interspersed through massive phosphate and arseniate of lead. Sometimes crystallized, and the crystals are regular six-sided prisms. I have not observed any modifications in the few crystals in my possession.

Opaque, or only slightly translucent on the edges; brittle.

Fracture even or flat conchoidal.

Lustre resinous.

Hardness 2·75; specific gravity 6·663.

Before the blowpipe on charcoal fuses with a good deal of frothing into a bead, which exactly resembles the original assay. When the fusion is continued, the matter spreads on the charcoal, and assumes at last the appearance of a black scoria. When carbonate of soda is added and the blast continued, globules of metallic lead are obtained, and a black scoriacious-looking matter continues. With borax it fuses into a bead transparent and red while in fusion, but on cooling it becomes suddenly opaque, and deep blue, if the proportion of vanadiate be considerable, but emerald green if it be small. When mixed in small proportion with biphosphate of soda, it melts into a beautiful emerald green transparent glass.

Its constituents, determined by the analysis of Dr. R. D. Thomson, in my laboratory, are

		Atoms	
Chlorine,	2·446	0·54	
Lead,	7·063	0·54	
Protoxide of lead,	66·326	4·74	1
Vanadic acid,	23·436	7·48	1·58
Peroxide of iron and silica,	0·163		
	99·434		

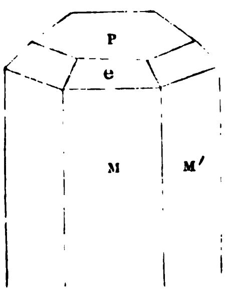
This is equivalent to

1 atom chloride of lead,
9 atoms sesquivanadiate of lead.

Sp. 8. *Arseniate of Lead.*

This mineral has been generally confounded by mineralogists with phosphate of lead. This is even done by Mohs, in his Mineralogy, though he is aware of the difference in the constitution of the two minerals. Fine specimens of it occur at Huel Unity, near Redruth in Cornwall, and in several others of the Cornish mines. It is found also at Beeralston, in Devonshire.

Colour pale yellow, passing into hair brown.



It occurs mamillary and compact, but generally crystallized in regular six-sided prisms, either perfect, or having the terminal edges replaced.

M on M′ 120°
P on M 90°
M on e 130°

Texture foliated. It cleaves parallel to the faces of the regular six-sided prism.

Lustre resinous; sectile.

Usually translucent. Said also to occur transparent, and then it is harder.

Hardness 2·75; specific gravity, as determined by Gregor, 6·41.

Before the blowpipe in a gold spoon it melts into a brownish yellow mass, which on cooling does not assume any angular form. On charcoal it gives out arsenical vapours in abundance, and a globule of metallic lead is obtained.

Dissolves easily in nitric acid, especially when assisted by heat.

Its constituents, determined by Wöler,* are

		Atoms.	
Chlorine,	2·56	0·56	0·15
Lead,	7·39	0·56	0·15
Arsenic acid,	21·09	2·9	0·9
Phosphoric acid,	1·32	0·29	0·09
Protoxide of lead,	67·64	4·83	1·5
	100·00		

Including the phosphoric acid with the arsenic, it is obviously a subsesquiarseniate of lead, composed of

1 atom arsenic acid,
1½ atom oxide of lead.

And this subsesquiarseniate is united with chloride of lead in the proportion of

7 atoms subsesquiarseniate of lead,
1 atom chloride of lead.

Sp. 9. *Cupreo-Chromate of Lead.*

Vauquelinite.

This mineral was observed by Berzelius accompanying the Siberian chromate of lead.†

Colour dark green, approaching olive green; powder and streak siskin green.

It occurs both massive and crystallized. The crystals are so small that their form cannot be recognised by the naked eye. When viewed with a glass they appear to be rhomboids, having nearly the same angles as chabasite; surface of the crystals specular splendent; streaked in the direction of the shorter diameter.

Soft enough to be scratched by the nail.

Fracture partly compact and having little lustre, or dull; partly earthy. In the first case the colour of the fracture is grey green, in the second pistachio green.

Before the blowpipe per se swells a little, and melts with much frothing into a dark grey bead, having the metallic lustre, round which globules of metallic lead may be observed. The greatest part of the bead remains unaltered, even in a high temperature. In borax it dissolves easily and with frothing into a black opaque glass. If the proportion of the assay be small, the glass is green; and if it be kept in the exterior flame it remains transparent after cooling; but in the reducing flame it becomes, while cooling, ruby red, opaque red, or altogether black. This red colour, proceeding from copper, becomes more conspicuous when a little tin is added. With biphosphate of soda it behaves in the same way. With carbonate of soda on charcoal it fuses and is absorbed; on platinum foil it fuses readily with effervescence to a transparent mass which is green while in fusion, but becomes fine yellow on cooling. This circumstance shows the presence of chromium. The yellow mass, dissolved in a drop of water, gives a yellow colour to the liquid, and throws down lead yellow from its solutions.

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* Poggendorf's Annalen, iv. 167. The specimen was from Johangeorgenstadt.

† Afhandlingar, vi. 246.

Its constituents, as determined by Berzelius, are as follows:

		Atoms.
Chromic acid,	28·33	4·35
Protoxide of lead,	60·87	4·35
Oxide of copper,	10·80	2·14
	100	

Obviously a compound of
2 atoms chromate of lead,
1 atom oxide of copper.

Sp. 10. *Sexaluminate of Lead.*

Plombgomme.

This mineral occurs at Huel Goet, near Poullaouen, in Brittany. It was noticed by Gillet Laumont in 1786.*

Colour yellowish and reddish-brown, striped.

Reniform; translucent.

Hardness 4·5.

Resembles Muller's glass so much, except in colour, that it might be taken for it. When suddenly heated it decrepitates violently, but when slowly heated it becomes white and opaque.

With borax it yields a transparent colourless glass. On charcoal it does not melt, but becomes an enamel like some of the zeolites.

Its nature was first ascertained by Mr. Smithson Tennant. Berzelius analyzed it† and obtained the following constituents:

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* Jour. de Phys. 1786, p. 385.

† Ann. des Mines, v. 245.

		Atoms.	
Alumina,	37	16·44	5·72
Protoxide of lead,	40·14	2·87	1
Water,	18·80	16·71	5·82
Sulphurous acid,	0·20		
Lime, oxides of iron and manganese,	1·80		
Silica,	0·60		
	98·54		

These numbers approach

6 atoms alumina,
1 atom protoxide of lead,
6 atoms water.

The alumina appears to act the part of an acid. It is a hydrous sexaluminate of lead.

4. *Triple Oxygen Salts of Lead.*

Sp. 1. *Cupreous Sulphato-Carbonate of Lead.*

This mineral has been observed only at Leadhills. It was noticed by Mr. Sowerby, in his British Mineralogy, under the name of *Green Carbonate of Copper*. It was first described and analyzed by Mr. Brooke.*

Colour deep verdigris green, inclining to mountain green, if the crystals be very delicate; streak greenish white.

It occurs in crystals which are generally very minute, and appear sometimes in small bunches, radiating from their common point of attachment to the matrix. It yields to mechanical division parallel to the planes of a right rhombic prism of 95° and 85°. The prism divides also in the direction of its shorter diagonal; and its height is to the edge of the base as 2 to 1.

Lustre resinous; translucent; rather brittle.

Hardness 2·5 to 3; specific gravity, as determined by Brooke, 6·4.

Its constituents, according to Mr. Brooke, are

		Atoms.	
Sulphate of lead,	55·8	2·93	7·46
Carbonate of lead,	32·8	1·95	5
Carbonate of copper,	11·4	1·57	4
	100		

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* Edin. Phil. Jour. iii. 119.

These numbers agree nearly with

7½ atoms sulphate of lead,
5 atoms carbonate of lead,
4 atoms carbonate of copper.

Which must be the constitution of the mineral.

Sp. 2. *Hedyphan.*

This name has been given by Breithaupt to a mineral found at Longbanshyttan, in Sweden, along with brown garnet, and bisilicate of manganese.

Colour white.

Occurs in amorphous masses, traversed by numerous rents; also, according to Breithaupt, in short six-sided pyramids.

Translucent.

Lustre adamantine, passing sometimes into resinous.

Hardness 4·5 to 5; specific gravity 5·460 to 5·493.

Before the blowpipe it fuses into an opaque globule, which does not crystallize on cooling. It tinges the flame greenish-blue, without giving out any smell. When heated with biphosphate of soda it froths, and the odour of muriatic acid is perceived. When fused upon charcoal, globules of lead are obtained, and a white smoke given off with the odour of arsenic. A scoria remains which is not reducible in the interior flame, but crystallizes on cooling. No fluoric acid could be detected in it.

Its constituents, according to the analysis of Kersten,* are as follows:

		Atoms.	
Protoxide of lead,	52·950	3·78	7·4
Lime,	14·034	4·01	8·91
Chlorine,	2·029	0·45	1
Arsenic acid,	22·780	3·14	7
Phosphoric acid,	8·207	1·82	4
	100·000		

Subtracting 0·45 atom from the lead, as united with the chlorine, there remain 3·33 atoms, which, with the lime, make 7·34 atoms. The atoms of phosphoric and arsenic acid together amount to 4·96. Now 7·34 is to 4·96 very nearly as 1·5 to 1, showing that the mineral consists of subsesquisalts. The atomic numbers correspond nearly with

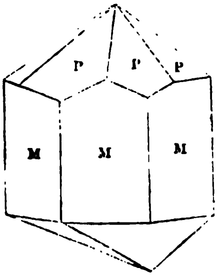
4 atoms subsesquiphosphate of lime,
2 atoms subsesquiarseniate of lime,
5 atoms subsesquiarseniate of lead,
1 atom chloride of lead.

These numbers therefore must represent the chemical constitution of this mineral.

5. *Sulphur Salts of Lead.*

Sp. 1. *Zinkenite.*

This mineral was discovered by M. Zinken, at Wolfsberg, near Stolberg, in the eastern Hartz. It was named by M. G. Rose, in honour of the discoverer. To him we are indebted for the first description of it.



Colour steel grey.

Hitherto found only in crystals. The crystals are six-sided prisms, terminated by low six-sided pyramids. The faces M, M, M are longitudinally streaked.

M on M about 120°
P on P 165° 26′

according to the measurement of M. G. Rose, but the faces are not smooth enough for actual measurement. He found M on M in some cases 120° 39′, and he conjectures that the prism is not regular, but, like arragonite, made up of three right oblique four-sided prisms, with angles of 120° 39′ and 59° 21′.

Lustre strongly metallic; opaque.

Hardness 3 to 3·5; specific gravity 5·303.

The crystals are usually grouped together, and are disposed on quartz.

Before the blowpipe on charcoal zinkenite decrepitates strongly, and fuses easily like sulphuret of antimony. No metallic globule appears, but the charcoal is coated with a powder partly yellow and partly white. In a glass tube it decrepitates and melts, a white smoke fills the tube, and the smell of sulphurous acid becomes sensible, and a little oxide of lead appears. With carbonate of soda on charcoal, a little globule of lead appears.*

The constituents of zinkenite, determined by the analysis of M. H. Rose,† are

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* *Poggendorf's* Annalen, vii. 91.

† Ibid. viii. 99.

			Atoms.
Sulphur,	22·58	11·29	4·56
Lead,	31·84	2·45	1
Copper,	0·42	0·10	—
Antimony,	44·39	5·55	2·26
	99·23		

If we admit the copper to be combined with sulphur, and to be accidental. It is obvious that the antimony is in the state of sesquisulphide, and the lead of sulphuret; the former acts the part of an acid, and the latter of a base. The mineral is a compound of

2 atoms sesquisulphide of antimony,
1 atom sulphuret of lead.

It is a *bisulpho-antimonite of lead.*

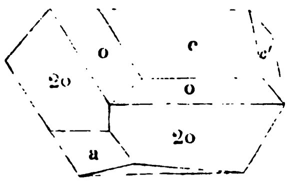
Sp. 2. *Plagionite.*[*]

This mineral was observed by M. Zinken at Wolfsberg. It bears a considerable resemblance to zinkenite, though its characters and constitution are sufficiently marked to entitle it to rank as a peculiar species.

Colour blackish lead-grey.

The form of the crystal is that represented in the margin, an octahedron deeply truncated in both its apices.

2o on 2o 120° 49′ according to the measurement of M. G. Rose. The three axes of the octahedron are to each other as 1 : 0·88 : 0·37.



The faces c are smooth, and have a strong metallic lustre. The other faces have less lustre, and are streaked, especially the faces 2o and o′ and the face a. The face a obviously replaces one of the angles of the octahedron.

Fracture imperfect conchoidal.

Structure foliated with two cleavages.

Brittle.

Hardness 2·5; specific gravity 5·4.

Before the blowpipe decrepitates, and fuses easily with the evolution of sulphurous acid, oxide of antimony, and oxide of lead, with which the charcoal is covered. It gives no indication of containing copper. With carbonate of soda after roasting, a button of lead is obtained, containing a little antimony, and a very minute portion of silver.

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[*] Zinken, Poggendorf's Annalen, xxii. 492. G. Rose, Ibid. xxviii. 421. The name is derived from πλαγιος, oblique; because the crystals exhibit no right angles.

Its constituents, determined by the analysis of M. H. Rose, are

		Atoms.
Lead,	40·52	3·11
Antimony,	37·94	4·74
Sulphur,	21·53	10·76
	99·99	

3·11 is to 4·74 very nearly as 2 to 3. It is obvious that the lead is in the state of sulphuret, and the antimony of sesquisulphide. Hence the mineral is a compound of

3 atoms sesquisulphide of antimony,
2 atoms sulphuret of lead;

or, dividing by two, of 1½ atom sesquisulphide of antimony, and 1 atom sulphuret of lead. It is therefore a *sesquisulpho-antimonite of lead*, so that it differs from zinkenite by containing half an atom less of sesquisulphide of antimony.

Sp. 3. *Jamesonite.*[*]

This mineral was first accurately distinguished from sesquisulphide of antimony, and named by Mohs in honour of Professor Jameson of Edinburgh. It occurs in masses of considerable dimensions in Cornwall and in Hungary, but its locality is not exactly known.

Colour steel grey; streak the same.

It occurs massive and crystallized, in four-sided oblique prisms,

M on T 101° 20′

The position of the base of the prism has not been ascertained.

Fracture not observable.

Lustre metallic; opaque; sectile.

Hardness 2 to 2·5; specific gravity 5·564.

Its constituents, as determined in three separate analyses by H. Rose,[†] are:—

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[*] In honour of Mr. Jameson, Professor of Natural History in Edinburgh.

[†] Poggendorf's Annalen, viii. 101. In the third analysis the quantity of sulphur was not determined.

				Mean.	Atoms.
Sulphur, . . .	22·15	22·53	—	22·34	11·17
Lead, ...	40·75	38·71	40·35	40	3·09
Do. with trace of iron and zinc,	—	0·74	—	— 18	—
Copper, ...	0·13	0·19	0·21	0·14	0·03
Iron, ...	2·30	2·65	2·96	2·64	0·75
Antimony, . . .	34·40	34·90	33·47	34·26	4·28
	99·73	99·72			

If we admit the iron to have been in the state of cubic pyrites, and the copper in that of sulphuret, and both to be accidental impurities, the sulphur will be reduced to 9·64 atoms. Of this, 3·09 atoms must be united to the lead. There remain 6·55 atoms of sulphur to unite with 4·28 atoms of antimony. Now, 6·55 is to 4·28 very nearly as 1·5 to 1. So that the antimony is in the state of sesquisulphide. And the mineral is a compound of

4·28 atoms sesquisulphide of antimony,
3·09 atoms sulphuret of lead.

Or very nearly

4 atoms sesquisulphide of antimony,
3 atoms sulphuret of lead.

Or, dividing by two, we may consider it as a compound of 2 atoms sesquisulphide of antimony, and 1½ atoms sulphuret of lead. It differs from the following species by wanting half an atom of sulphuret of lead.

Sp. 4. *Feather Ore of Lead.*

This mineral was long confounded with *sesquisulphide of antimony*, under the name of plumose antimonial ore. It was recognised as a peculiar ore, in consequence of the chemical analysis of it by M. H. Rose. The specimen examined was from Wolfsberg, in the eastern Hartz. But it occurs also in Saxony, Hungary, and other localities.

Colour lead-grey.

Crystallized in long flexible crystals of the size of a hair, somewhat like asbestus. It fills the drusy cavities of quartz, and looks at first like a cobweb. From the extreme smallness of the size, the shape of the crystals has not been determined.

Lustre glistening, semimetallic.

Opaque; soft; specific gravity not determined; sectile.

When put into the flame of a candle it melts almost immediately, giving out a white smoke.

Its constituents, as determined by Rose,* are

		Atoms.
Sulphur,	19·72	9·86
Antimony,	31·04	3·88
Lead,	46·87	3·60
Iron,	1·30	0·37
Zinc,	0·08	0·02
	99·01	

If we consider the iron as in the state of cubic pyrites, and the zinc in that of a sulphuret, and both as accidental impurities, there will remain 9·1 atoms of sulphur, 3·6 of which must be united with the lead. There remain 5·5 atoms of sulphur to combine with 3·88 atoms of antimony, constituting very nearly sesquisulphide of antimony. But 3·88 and 3·60 being very nearly equal, it is obvious that the mineral consists of

1 atom sesquisulphide of antimony,
1 atom sulphuret of lead.

It is therefore a simple sulpho-antimonite of lead.

If we double both constituents, it will become obvious that it contains exactly half an atom of sulphuret of lead more than Jamesonite.

Sp. 5. *Nagyag tellurium ore.*

This mineral, from Nagyag, is exposed to sale in Paris, under the name of *blättererz*, though it is quite different from that mineral, and ought to constitute a species apart. I place it here, because it seems to consist essentially of a peculiar combination of sesquisulphide of antimony and sulphuret of lead, different from any of the preceding species. For its analysis and an imperfect description, we are indebted to Berthier.†

Colour iron-black, inclining to lead-grey.

It occurs in curved plates interlaced together, disseminated in bisilicate of manganese.

Lustre splendent.

Specific gravity 6·84.

Its constituents, determined by the analysis of Berthier, are

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* Poggendorf's Annalen, xv. 471.

† Memoires par Berthier, ii. 221.

		Atoms.
Gold,	6·7	0·53
Tellurium,	13·0	4·25
Lead,	63·1	4·85
Antimony,	4·5	0·56
Copper,	1·0	0·25
Sulphur,	11·7	5·85
	100·0	

4·85 atoms lead require 4·85 atoms sulphur to convert them into sulphuret. Doubtless the copper was in the state of sulphuret, and an accidental impurity. There remain 0·75 sulphur to combine with 0·56 antimony, constituting sesquisulphide of antimony; now 0·56 is to 4·85 nearly as 1 to 9, so that the principal part of the mineral is a compound of

1 atom sesquisulphide of antimony,
9 atoms sulphuret of lead.

The gold and tellurium probably constitute merely a mechanical mixture. If they are chemically combined with each other, as may be the case, they consist of

1 atom gold,
8 atoms tellurium.

The octotelluret of gold is to enneasulpho-antimonite of lead nearly in the proportion of 6 to 7. We may therefore consider the nagyag ore as a mixture of

6 atoms octotelluret of gold,
7 atoms enneasulpho-antimonite of lead.

It will be worth while to exhibit a tabular view of these five minerals, that the relation between them may be perceived at a glance.

Let $StS^{1\frac{1}{2}}$ be the symbol for sesquisulphide of antimony, and $\dot{P}lS$ for sulphuret of lead.

The composition of each is as follows:

1. Zinkenite, $2St\dot{S}l^{1\frac{1}{2}}+Pl\dot{S}l$.
2. Plagionite, $1\frac{1}{2}St\dot{S}l^{1\frac{1}{2}}+Pl\dot{S}l$.
3. Jamesonite, $2St\dot{S}l^{1\frac{1}{2}}+1\frac{1}{2}\ Pl\dot{S}l$.
4. Feather ore, $2St\dot{S}l^{1\frac{1}{2}}+2Pl\dot{S}l$.
5. Nagyag ore, $St\dot{S}l^{1\frac{1}{2}}+9Pl\dot{S}l$.

GENUS XXI.—TIN.

Though *tin*, where it happens to occur, is generally found in considerable quantity, it is nevertheless a much rarer metal than any of the others which have, from time immemorial, been in common use. The ores are very few, only two species being known. These are *peroxide of tin* and *cupreous sulphuret of tin.*

Sp. 1. *Peroxide of Tin.*

Tinstone, wood tin, tin ore.

This species, from which nearly all the tin of commerce is extracted, occurs only in primary rocks, where it is found both in veins and disseminated. Granite, gneiss, mica slate and clay slate are the usual formations in which it is found. It abounds in Cornwall, Saxony and Bohemia, and in the peninsula of Malacca and island of Banca, in India. It is said also to occur in Chili. In minute quantity it has been found in the rocks near Fahlun, in the Albite rock at Chesterfield, Massachusetts, and in many other places.

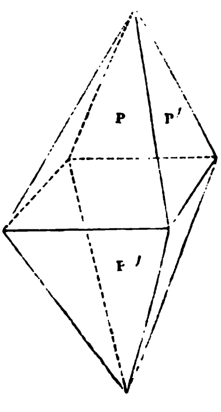
In Cornwall it has been smelted from time immemorial. The Tyrians appear to have traded with Cornwall for tin as early as the time of Moses; depôts of it seem to have been established on St. Michael's Mount, called Iktis (ἴκτις), by the Greeks, whence it was transported to those countries that required it.

Colour various shades of white, grey, yellow, red, brown, black; streak pale grey, sometimes pale brown.

Usually in crystals. The primary form is an octahedron with a square base.

P on P′ 133° 30′
P on P″ 67° 50′

According to the measurement of Mr. W. Phillips. The angle over the apex is 112° 10′. It never occurs under this form; the nearest to it is a four-sided square prism, terminated by four-sided pyramids, or the primary form with a prism interposed between the pyramids. It occurs under a great variety of modifications, and very commonly in macles, consisting of two crystals interwoven together.



Structure foliated; surface of the prisms often vertically streaked.

Lustre *adamantine.*

Sometimes nearly transparent, often semitransparent; frequently opaque; brittle.

Hardness 6·5; specific gravity, by my trials, from 6·55 to 6·945.

Alone it does not melt before the blowpipe, but is reducible on charcoal, especially if assisted by the addition of a mixture of borax and carbonate of soda.

Insoluble in acids.

Its constituents are as follows:

	*	*	†	‡	§
Peroxide of tin,	99	99·5	95	93·6	96·265
Oxide of columbium,	—	—	—	2·4	—
Peroxide of iron,	0·25	0·5	5	1·4	3·395
Sesquiox. of mangan.,	—	—	—	0·8	
Silica, . .	0·75	—	—	—	6·750
	100	100	100	98·2	100·41

It consists essentially of oxide of tin; yet, in some specimens, silica appears to enter into the constitution of the mineral. The specimen analyzed by me is a compound (neglecting the peroxide of iron) of

3 atoms peroxide of tin,
1 atom silica.

Wood tin is distinguished by its fibrous texture and its brown colour, imitating the texture of wood. It was formerly very abundant in Cornwall. Fine specimens have been brought from Mexico.

Sp. 2. *Cupreous Sulphuret of Tin.*

Tin pyrites, bell metal ore.

This species has been found only in Cornwall. It occurs in a vein nine feet wide, in Huel Rock in the parish of St. Agnes, accompanied by blende and sulphuret of iron. Some other Cornish localities have been also mentioned.

Colour steel-grey; yellowish-white or brass-yellow; streak black.

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[*] Klaproth, Beitrage, ii. 256.

[†] Collet Descotils, Ann. de Chim. liii. 268.

[‡] Berzelius, Afhandlingar, iv. 164. The specimen was from Finbo; colour black; specific gravity 6·55.

[§] By my analysis. A reddish-brown specimen from Cornwall; specific gravity 6·945.

Usually massive, but it has been observed also crystallized in regular hexahedrons; lustre metallic; opaque; brittle.

Hardness 3·25; specific gravity 4·350, as determined by Klaproth.

Before the blowpipe sulphur is driven off, and the mineral melts into a blackish scoria without yielding a metallic button.

It dissolves in nitromuriatic acid, the sulphur being partly left behind.

The following, according to Klaproth, are the constituents of this mineral:

Sulphur,	25	30·5
Tin,	34	26·5
Copper,	36	30
Iron,	2	12
	97*	99†

If these analyses be accurate, it is not easy to avoid considering the mineral rather as a mechanical mixture than a chemical compound. The first analysis gives us

	Atoms.
Sulphur,	12·5
Tin,	4·69
Copper,	9·0
Iron,	0·57

If the iron was in the state of cubic pyrites, it would be combined with 1·14 atom sulphur. The copper would be united with 9 atoms sulphur, leaving 2·36 atoms sulphur, combined with 4·69 atoms tin. So that the tin must have been in the state of disulphuret. The mineral consisted of

0·57 atom iron pyrites,
9 atoms sulphuret of copper,
4·69 atoms disulphuret of tin.

These numbers are nearly equivalent to

1 atom iron pyrites,
8 atoms disulphuret of tin,
16 atoms sulphuret of copper.

The second analysis gives us

	Atoms.
Sulphur,	15·25
Tin,	3·65
Copper,	7·5
Iron,	3·42

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[*] Beitrage, ii. 259.

[†] Ibid. v. 228.

If the iron be in the state of cubic pyrites, it will take 6·84 atoms of sulphur. There will remain 8·41 atoms. If the copper take 7·5 atoms, there will remain only 0·90 atom of sulphur to combine with 3·65, which would make a tetrakisulphuret of tin, instead of a disulphuret. The constituents would be

3·42 atoms cubic pyrites,
7·5 atoms sulphuret of copper,
3·65 tetrakisulphuret of tin.

These correspond nearly to

1 atom cubic pyrites,
2 atoms sulphuret of copper,
1 atom tetrakisulphuret of tin.

I think it probable, from the mode of analysis followed, that the quantity of sulphur is underrated.

GENUS XXII.—BISMUTH.

The ores of *bismuth* are not numerous, and like those of tin, they consist chiefly of combinations of the metal with simple bodies. The native salts of bismuth are few. Saxony is the country where the greatest part of the bismuth of commerce is procured; though specimens of some of the ores are found in Cornwall.

1. *Native, or combined with Simple Bodies.*

Sp. 1. *Native Bismuth.*

This mineral occurs most abundantly at Johan-georgenstadt, and Schneeberg, in Saxony, and at Joachimsthal, in Bohemia. Fine specimens have been obtained from the tin mine of Altenberg. It has been met with also in France, Sweden, Norway, Connecticut, and in Botallack, and at St. Columb, and at Huel Sparnan in Cornwall, and also at Carroch in Cumberland.

Colour silver-white, with a tint of red; streak similar.

Massive, also crystallized in acute rhomboids and in regular octahedrons.

Texture lamellar, and it cleaves parallel to the faces of the regular octahedron.

Surface rough, generally covered with oxide.

Lustre metallic; sectile; opaque.

Hardness 3·25; specific gravity 9·737

It melts even at the flame of a candle. Before the blowpipe it is gradually dissipated in a yellow smoke, which is deposited on the charcoal.

Dissolves in nitric acid. When the solution is sufficiently diluted, a white curdy precipitate falls.

I am not aware that this mineral has been subjected to analysis. As the bismuth of commerce is merely the native bismuth melted out of the stony matrix in which it is found, it is obvious that native bismuth consists almost entirely of the pure metal. It is not, however, quite free from sulphur.

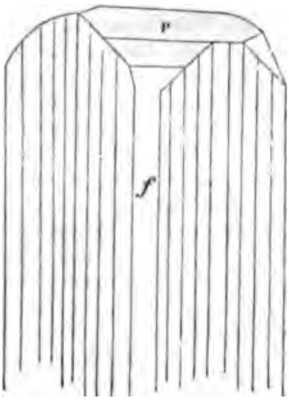
Sp. 2. *Sulphuret of Bismuth.*

Bismuth glance.

This mineral occurs chiefly in veins, though it has been found also in beds. It is rather rare. Saxony and Bohemia are the most abundant localities. But it occurs also in Cornwall, and at Riddarhyttan in Sweden.

Colour lead-grey, inclining a little to steel-grey; streak similar.

It occurs massive and crystallized in small prisms, too minute to determine the exact dimensions. It cleaves parallel to the faces P and *f*, and at right angles to *f*. There are also indications of cleavage parallel to the planes of a right rhombic prism of about 130° and 50°. The principal cleavage is parallel to the face *f*. The other faces of the prism are longitudinally streaked.



Mr. W. Phillips measured some artificial crystals of sulphuret of bismuth, and found them rhombic prisms of 91° and 89°.

Lustre metallic; opaque; rather sectile.

Hardness 2·75; specific gravity 6·549.

It is volatilized before the blowpipe, and covers the charcoal with a yellow areola. It is very fusible, and gives off continually small drops in a state of incandescence.

Dissolves readily in hot nitric acid. When the solution is diluted with water, a white precipitate falls.

* *Phil.* Mag. (2d series), ii. 181.

Its constituents, as determined by the analysis of M. H. Rose,* are

		Atoms.
Sulphur, .	18·72 .	9·36
Bismuth, .	80·98 .	8·99
	99·70	

This is obviously

1 atom sulphur,
1 atom bismuth.

It is a simple sulphuret of bismuth.†

Sp. 3. *Ferruginous Arseniet of Bismuth.*

This mineral occurs at Schneeberg in Saxony.

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* Gilbert's Annalen, lxxii. 192. The specimen was from Ridderhyttan. Wehrle's analysis, noticed by Berzelius (Jahres-Bericht, 1833, p. 177), almost coincides with this. He obtained

		Atoms.
Sulphur, . .	18·28 .	9·14
Bismuth, . .	80·96 .	8·99
	99·24	

† Mr. Warrington has given us the analysis of a sulphuret of bismuth found in the western parts of Cornwall, which differs from the species described in the text, by containing a mixture of sulphurets of iron and copper, probably accidental. See Phil. Mag. (new series), ix. 29.

It occupies the cavities and fissures of a porous mass of yellow copper pyrites and silica, in the form of striated needles and bands. External colour iron-grey, internally it resembles polished steel. Specific gravity 5·85; hardness 2·7.

When heated before the blowpipe on charcoal, it inflames, and when the heat is increased for some time, it appears to be entirely volatilized, with the exception of a minute globule of brown scoriaceous matter.

Its constituents, determined by an analysis conducted with great care, were as follows:

		Atoms.
Bismuth, . .	68·53 .	7·6
Sulphur, . .	19·33 .	9·6
Iron, . . .	2·90 .	0·82
Copper, . .	2·98 .	0·74
Silica, . . .	5·01	
	98·75	

This is obviously

7·6 atoms sulphuret of bismuth,
0·8 atom sulphuret of iron,
0·74 sesquisulphuret of copper.

Abstracting the two last compounds, which probably may not exist in chemical combination, the mineral will agree with the species described in the text.

Colour externally, dark hair brown; internally, brownish yellow.

Massive; composed of plates or columns applied to each other.

Lustre resinous; brittle.

Hardness 5·5; specific gravity 3·694.

It decrepitates briskly before the blowpipe, emits an arsenical odour, and burns with a blue flame, being either dissipated or fused into a metallic globule, according to circumstances.

Soluble in nitric and muriatic acid.

Its constituents, by my analysis, are

			Atoms.
Arsenic,	38·092	8·02	4
Bismuth,	55·913	6·21	3·09
Iron,	6·321	1·80	0·9
	100·326		

These numbers correspond with

4 atoms arsenic,
3 atoms bismuth,
1 atom iron.

Hence the mineral consists of

3 atoms arseniet of bismuth,
1 atom arseniet of iron.

Sp. 4. *Arsenic Glance.*

This mineral, which occurs at Palmbaum, near Marienberg, was first noticed by Freisleben. Berzelius announced, in the year 1827, that it was a compound of

12 atoms arsenic,
1 atom sulphur.

But it was analyzed by M. Kersten,* who found the constituents

Arsenic,	96·785
Bismuth,	3·001
	99·786

And though he searched for sulphur he could detect none. It is obvious from this, that Berzelius and Kersten experimented on two different minerals. We have no accurate description of either. But they seem rather entitled to be considered as varieties of native arsenic, than as peculiar species. Berzelius's mineral is a compound of

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* Poggendorf's Annalen, xxvi. 492.

Arsenic,	.	96·61
Sulphur,	.	3·39
		100·00

While that of Kersten consists of

40½ atoms arsenic,
1 atom bismuth.

It seems unreasonable to consider such combinations as chemical compounds.

Sp. 5. *Telluret of Bismuth.*

This mineral was first noticed by Baron Von Born, and considered by him as a compound of silver and bisulphide of molybdenum.[*] It was afterwards examined by Klaproth, who stated it to be a compound of 95 bismuth and 5 sulphur.[†] More lately, Berzelius subjected it to the action of the blowpipe, and found it to be chiefly composed of tellurium and bismuth.[‡]

It was discovered first at Deutch Pilsen, in Hungary. Berzelius recognised it in a specimen from Riddarhyttan.

Colour silver-white.

Composed of broad plates laid on each other.

Lustre metallic; opaque.

Hardness 2; stains paper like sulphuret of molybdenum. Specific gravity, according to Baumgärtner, 7·514; according to Wehrle, 7·500.

May be divided into thin plates, like sulphuret of molybdenum. Found crystallized in small crystals, having the aspect of six-sided prisms, but Haidinger has shown that they consist in reality of two different rhomboids united together.[§]

Before the blowpipe melts the instant it is exposed to heat, and gives out a yellow metallic vapour.

Berzelius detected in it a little sulphur and selenium; but found its chief constituents to be bismuth and tellurium. Wehrle subjected it to a chemical analysis, and found its constituents to be

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[*] Catalogue de la Collection des fossiles de Mlle. de Raab, ii. 419.

[†] Beitrage, i. 253.

[‡] Kong. Vet. Acad. Handl., 1823, p. 183.

[§] See Poggendorf's Annalen, xxi. 596.

		Atoms.
Bismuth,	59·84	6·65
Tellurium,	35·24	8·81
Sulphur,	4·92	2·46
	100·00	

Berzelius obtained

Bismuth,	58·30
Tellurium,	36·05
Sulphur,	4·32
Matrix,	0·75
	99·42 with a trace of selenium.

It is obviously a compound of

1 atom sulphuret of bismuth,
2 atoms bitelluret of bismuth.

Its formula is $BisS+2BisTel^2$.

The so-called molybdenum silver of Deutch Pilsen, was also analyzed by Wehrle. Its specific gravity is 8·44. Its constituents

		Atoms.
Bismuth,	61·15	6·8
Tellurium,	29·74	7·43
Silver,	2·07	0·17
Sulphur,	2·33	1·16
	95·29	

It would appear to consist of

6·8 atoms telluret of bismuth,
1 atom sulphuret of tellurium,
0·17 atom sulphuret of silver.

But the analysis is imperfect in consequence of the loss of 4·71 per cent.

Sp. 6. *Oxide of Bismuth.*

Bismuth ochre.

This rare mineral has been observed at Schneeberg and Joachimsthal.

Colour greenish yellow or yellowish grey.

Massive and disseminated.

Fracture fine grained uneven, passing into foliated and earthy.

Lustre adamantine; that of the fine grained uneven, glimmering; *of the foliated*, shining; of the earthy, dull.

Opaque; soft, often friable; specific gravity, according to Büsson, 4·3611.

Before the blowpipe on charcoal it is easily reduced to the metallic state, and the greatest part may be afterwards dissipated.

It is said to have been analyzed by Lampadius, with the following result:

		Atoms.
Oxide of bismuth,	86·4	8·63
Oxide of iron,	5·1	1·15
Carbonic acid,	4·1	1·49
Water,	3·4	3·02
	99·0	

If the iron was in the state of protoxide, the mineral may be considered as a mixture of

7½ atoms oxide of bismuth,
1 atom carbonate of iron,
2½ atoms water.

I suspect strongly, that this species and the next will be found ultimately the same.

2. *Simple Oxygen Salts of Bismuth.*

Sp. 1. *Carbonate of Bismuth.*

This mineral was found at St. Agnes, Cornwall. It is an earthy substance of a dirty yellow colour. Mr. Gregor examined it, and found it to consist essentially of carbonic acid and bismuth. The small fragment of it in my possession, consists chiefly of earthy matter. It does not effervesce sensibly in acids, and contains only traces of bismuth. I think it likely, that ultimately bismuth ochre and carbonate of bismuth, will turn out one and the same mineral. We still want a good analysis of both. I have never been able to procure specimens of either fit for an accurate analysis.

Sp. 2. *Silicate of Bismuth.*

Bismuth blende—kieselwismuth—arsenical bismuth of Breithaupt.

This mineral is found in the neighbourhood of Schneeberg. It was first described and named by Breithaupt.*

Colour clove-brown and reddish brown; streak yellowish-grey.

* Poggenderf's Annalen, ix. 275.

It is usually crystallized. The primary form, according to Breithaupt, is the rhomboidal dodecahedron. But it occurs also in tetrahedrons, hexahedrons, and pyramidal dodecahedrons.

Varies from opaque to semitransparent; brittle; not very difficultly frangible.

Hardness 5·5 to 6; specific gravity from 5·912 to 6·006.

When heated in a glass tube it decrepitates, giving out a trace of water.

Before the blowpipe it fuses to a dark yellow mass, and gives out a sublimate which is destitute of smell. On charcoal it fuses easily. The fused mass froths, and seems to give out a small quantity of gas. The charcoal round the assay is stained yellowish-brown, sometimes with a tint of green. With carbonate of soda it fuses easily into a button, at first greenish-yellow and then reddish-yellow. Globules of a brittle metal make their appearance, and the charcoal becomes coated with a yellowish-brown matter. No smell of arsenic could be perceived, nor any indication of the presence of sulphur.

Fused with borax in the oxidizing flame, it formed a glass yellowish-red while hot, then becoming yellowish-green, and when quite cold, opal coloured. When this glass was transferred from the platinum wire to charcoal, and the blast continued, it became grey and opaque. By little and little it frothed, and a button of reduced metal was obtained. With biphosphate of soda it entered into fusion, leaving a skeleton of silica. The glass while hot was yellow, but colourless when cold. An additional dose of the assay rendered the glass reddish-brown and then greenish-yellow while hot, but it became colourless when cold, or opal if the dose of the assay was great.

Its constituents, determined by a very careful analysis of Kersten,* are as follows:

		Atoms.	
Oxide of bismuth, .	69·38 .	6·94 .	1
Silica, . . .	22·23 .	11·11 .	1·6
Phosphoric acid, .	3·31 .	0·73	
Peroxide of iron, .	2·40 .	0·48	
Sesquioxide of mangan.,	0·30 .	0·06	
Fluoric acid and water,	1·01		
	98·63		

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* *Poggendorf's* Annalen, xxvii. 81.

If we admit the phosphoric acid to be in combination with the iron, forming a sesquiphosphate of iron, and if we allow that this substance is only accidental, then the mineral will be a sesquisilicate of bismuth, or a compound of

1½ atom silica,
1 atom oxide of bismuth.

3. *Sulphur Salts of Bismuth.*

Sp. 1. *Needle Ore of Bismuth.*

This mineral occurs in the mines of Pischminskoi and Klintzefskoi, near Berasof, in the district of Catherinenburg in Siberia, and was first described and analyzed by Karsten and John.

Colour steel-grey with a pale copper red tarnish.

Massive and crystallized in four or six-sided prisms, in which the lateral faces are longitudinally streaked.

Fracture uneven. Such of the crystals as I have seen traverse quartz.

Lustre metallic; opaque.

Hardness 5·25; specific gravity, as determined by John, 6·125.

Before the blowpipe sulphur is driven off, the assay melts and emits numerous sparkling metallic globules. A button of lead containing copper remains, which communicates a greenish blue colour to glass of borax.

Its constituents, as determined by John,* are

		Atoms.	
Bismuth,	43·20	4·8	2·55
Lead,	24·32	1·87	1
Copper,	12·10	3·02	1·6
Nickel?	1·58	0·48	
Tellurium?	1·32	0·33	
Sulphur,	11·58	5·79	
Gold,	0·79	0·06	
	94·89		

The loss of 5 per cent. in this analysis, renders it impossible to deduce from it the chemical constitution of the mineral. The atoms of metals are nearly twice as numerous as those of sulphur. Hence the metals must be in the state of disulphurets. If we admit the disulphurets of nickel, and tellurium, and the gold, to be accidental impurities, the bismuth, lead and copper, are to each other very nearly as the numbers 5, 2, 3. Hence the constituents are

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* Gehlen's Jour. (2d series), v. 227.

5 atoms disulphuret of bismuth,
3 atoms disulphuret of copper,
2 atoms disulphuret of lead.

Were we to admit the disulphuret of bismuth to act the part of an acid, and the other two that of bases, the constitution of needle ore would be

3 atoms sulphobismuthide of copper,
2 atoms sulphobismuthide of lead.

But a new analysis is still wanting, to fix our ideas about the constitution of this mineral.

GENUS XXIII.—COPPER.

Copper probably stands next to lead in abundance. The variety of its ores is considerable. It is found native, or combined with simple bodies; and it forms a greater number of oxygen salts than any of the metals except iron, while its sulph ursalts are as numerous as those of lead.

1. *Native, or combined with Simple Bodies.*

Sp. 1. *Native Copper.*

This mineral is rather common, both in veins and beds. In Cornwall it is rather abundant, in the mines around Redruth. Fine crystallized specimens come from Siberia; nor is it uncommon in Germany, Spain, Norway, America, &c.

Colour copper-red; streak unaltered.

Massive, and in strings and plates; often crystallized. The primary form is the cube; but it occurs also in octahedrons, rhombic dodecahedrons and icosahedrons.

Lustre metallic; opaque. Fracture hackly; ductile.

Hardness 2·75; specific gravity 8·5844, as stated by Hauy.

Before the blowpipe it fuses pretty easily, and is covered on cooling with a coat of oxide.

Dissolves easily in sulphuric acid; solution blue.

I am not aware that it has been subjected to analysis, but it consists almost entirely of metallic copper. If any other metal be present in minute quantity, its presence has not yet been detected.

Sp. 2. *Red Oxide of Copper.*

Red copper ore, octahedral copper ore, ziegelerz, tile ore.

This mineral occurs both in beds and veins; most commonly in primary rocks. One of the most abundant localities is Cornwall, but it occurs also in the Bannat of Temeswar, near Catherinenburg in Siberia, and at Chessy, near Lyons. The French specimens occur in sandstone, the Hungarian in gneiss. Many other localities might be named.

Colour between cochineal-red and lead-grey. When in capillary crystals almost carmine red; streak various shades of reddish-brown.

Massive and crystallized. Primary form of the crystals the regular octahedron, but it occurs also crystallized in cubes, cubo-octahedrons, rhomboidal dodecahedrons and acute rhomboids.

Lustre adamantine; sometimes imperfect metallic.

Semitransparent to translucent on the edges; brittle.

Hardness 3·5; specific gravity, according to Haidinger, 5·992.

Before the blowpipe, in the interior flame, it is reduced to a button of copper.

Soluble, with effervescence, in nitric acid; without effervescence in muriatic acid.

From the experiments of Klaproth and Chenevix, there can be no doubt that it is a suboxide of copper, composed of

2 atoms copper = 8 or 88·88
1 atom oxygen = 1 or 11·12

100

Sp. 3. *Black Oxide of Copper.*

This mineral is found in most of the Cornish mines where copper pyrites or red copper ore occurs. Carrarat and Tincroft mines may be mentioned as an example.

Colour black, or bluish or brownish-black.

Rarely massive; mostly disseminated through or covering other ores of copper.

Friable; composed of dusty particles which scarcely soil the fingers.

Heavy.

Before the blowpipe it is infusible, and does not give out a sulphureous odour. With borax it yields a greenish slag.

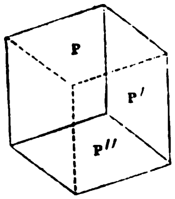
It has not been analyzed, but is considered as a mixture of oxides of copper and iron.

Sp. 4. *Disulphuret of Copper.*

Glance copper, sulphuret of copper, vitreous copper ore, kupferglas.

This is one of the commonest ores of copper. Fine specimens of it are found in Cornwall, near Redruth; and near Freyberg, where it is found in veins.

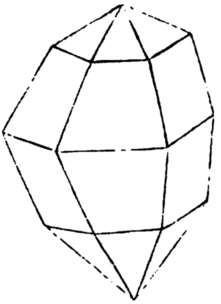
Colour blackish lead-grey; streak the same.



It occurs massive and crystallized. The primary form is an acute rhomboid.

P on P′ 71° 30′

This is the form obtained by cleavage, but the usual crystal is a regular six-sided prism, the terminal edges of which are usually replaced by planes, which, when complete, convert the crystal into a double six-sided pyramid. These pyramids are sometimes obtuse and sometimes acute, so that the dodecahedrons formed are either long or short. Sometimes the two dodecahedrons appear together in the same crystal, as in the figure in the margin.



Lustre metallic; opaque; very sectile.

Hardness 2·75; specific gravity of a very pure crystal, by my trial, 5·7022.

In the oxidizing flame of the blowpipe it melts, and emits glowing drops with a noise. In the reducing flame it becomes covered with a coat and does not melt. If the sulphur has been driven off, a globule of copper remains.

In hot nitric acid the copper dissolves, and most of the sulphur remains unacted on.

Its constituents are as follows:

	*	†	‡	Atoms.
Copper, .	78·5	76·5	77·16	19·29
Sulphur, .	18·5	22·0	20·62	10·31
Iron, .	2·25	0·5	1·45	0·41
Silica, .	0·75	—		
	100	99	99·23	

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* Klaproth, Beitrage, ii. 279. † Ibid. iv. 37.

‡ By my analysis. The specimen was a fine crystal from the united mines, Cornwall. Specific gravity 5·7022.

If we allow the iron to be in the state of cubic pyrites and an accidental impurity, it is obvious that the mineral is a compound of

1 atom sulphur,
2 atoms copper.

Or it is a disulphuret of copper.

Sp. 5. *Seleniet of Copper.*

From the analysis of M. H. Rose, given while giving an account of seleniet of lead (p. 552), it is evident that seleniet of copper exists among the seleniets found in the eastern part of the Hartz, but as it has not been seen in a separate state, no description can be given. Berzelius got from Svedenstjerna a small specimen of limestone through which some seleniet of copper was interspersed; it was heavy, had a silver-white colour and the metallic lustre. It dissolved completely in nitric acid. The solution was blue. It was scarcely precipitated by muriatic acid, and not at all by sulphuric acid or nitrate of barytes. Caustic ammonia in excess kept it wholly in solution. Carbonate of potash threw down carbonate of copper, and the residual liquor yielded selenium. From these experiments it appears that the mineral was a seleniet of copper, but the quantity was too small to admit of accurate analysis.*

Sp. 6. *Arseniet of Copper.*

White copper ore.

This mineral was noticed by Henkel, and was admitted by Werner as a peculiar species of copper ore, under the name of *weisskupfererz;* but it is very rare, and no locality is given by Hoffmann, but Mr. Jameson mentions Huel Garland in Cornwall, and several places in Germany and Hungary. I have never had an opportunity of seeing a specimen of this rare ore.

Colour intermediate between tin-white and brass-yellow.

Massive and disseminated.

Lustre metallic, glistening.

Fracture small and fine-grained, uneven.

Semihard; brittle; easily frangible; specific gravity, by De la Metherie, 4·500.

Before the blowpipe gives off arsenic, and melts into a greyish-black slag.

---

* Berzelius, Afhandlingar, vi. 142.

It has not been analyzed, but from the action of the blowpipe it is obvious that it consists of arsenic, copper and iron. According to Henkel, it contains 40 per cent. of copper.

2. *Simple Oxygen Salts of Copper.*

Sp. 1. *Anhydrous Dicarbonate of Copper.*

This species was first observed by Dr. Heyne in the peninsula of Hindostan, near the eastern extremity of the Mysore, where it appears to occur in nests in primary rocks. It was described and analyzed by me in 1813.*

Colour dark blackish-brown, when the mineral is pure; but in general small veins of green and red may be seen traversing it. These consist of malachite and red oxide of iron; streak reddish-brown.

Massive; has not been observed in crystals.

Fracture small conchoidal.

Some indications of a foliated structure may be occasionally observed.

Sectile; opaque.

Hardness 4·25; specific gravity 2·620.

Dissolves in acids, with the exception of a little red powder, consisting chiefly of peroxide of iron.

Its constituents, by my analysis, are

		Atoms.
Carbonic acid,	16·70	6·07
Oxide of copper,	60·75	12·15
Peroxide of iron,	19·50	
Silica,	2	
	99·05	

The peroxide of iron and silica are foreign bodies, which traverse the mineral in small veins visible to the naked eye. It is obvious that the pure mineral is a compound of

1 atom carbonic acid,
2 atoms oxide of copper;

or it is a dicarbonate of copper.

I am not aware that this species has been observed in Europe. But it may be formed artificially.

---

* Phil. Trans. 1814, p. 45.

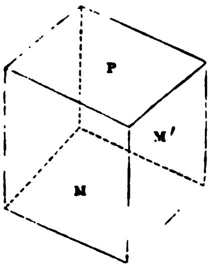
Sp. 2. *Hydrous Dicarbonate of Copper.*

Malachite—mountain green—atlaserz.

This species occurs both in veins and beds, and in rocks of various ages. Fine specimens are brought from Siberia, from Chessy in France, and Moldawa in the Bannat of Temeswar. It is rare in Cornwall.

Colour green of various kinds; grass green, emerald green, verdigris green; streak green, but rather paler.

Massive. Texture sometimes earthy, sometimes compact, and sometimes fibrous. The fibres are exceedingly slender. They are frequently fasciculated. In cavities we sometimes see minute and transparent crystals, commonly macles. These crystals yield by mechanical division an oblique rhombic prism.



P on M or M′ 112° 52′
M on M′ 107° 20′

According to the measurements of Mr. Brooke. Mr. Phillips makes the primary form a right rhombic prism.

Lustre adamantine, inclining to vitreous; sometimes silky.

Translucent, sometimes only on the edges; brittle.

Hardness 4; specific gravity 4·008, as determined by Haidinger.

Before the blowpipe it decrepitates, becomes black, remains partly infusible, and is partly converted into a black scoria. In borax it dissolves, communicating a deep green colour, and leaving a button of metallic copper.

Its constituents are as follows:—

	*	†	Mean.	Atoms.	
Carbonic acid,	18	21·25	19·62	7·13	1
Oxide of copper,	70·5	70·00	70·25	14·05	1·97
Water, .	11·5	8·75	10·125	9	1·26
	100	100			

These numbers obviously correspond with

1 atom carbonic acid,
2 atoms oxide of copper,
1 atom water.

I analyzed a specimen of pure malachite, having a silky lustre and a specific gravity of 3·9122, by exposing it to a red heat in a bottle glass retort, to the mouth of which a tube filled with chloride of calcium was attached. The result was

---

* Klaproth, Beitrage, ii. 287.

† Vauquelin, Hauy's Mineralogie, iii. 491.

			Atoms.
Carbonic acid,	19·98	7·26	1
Oxide of copper,	72·69	14·54	2
Water,	7·31	6·5	0·895
	99·98		

The carbonic acid and oxide of copper are exactly 1 and 2 atoms. The water is less than 1 atom. The mineral had been many years in my cabinet. Had it lost a little of its water?

The mineral consequently is a *hydrous dicarbonate of copper*, differing from the preceding species by the presence of an atom of water, to which it obviously owes its green colour.

Sp. 3. *Sulphate of Copper.*

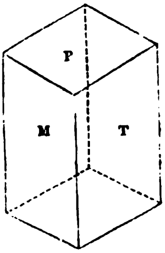
Blue vitriol.

This salt owes its existence to the decomposition of different ores of copper, especially copper pyrites. It is found dissolved in several waters, partly issuing from mines. These have received the name of waters of *cementation*. Its chief localities are Rammelsberg, near Goslar; Neusohl, in Hungary; Anglesea; Wicklow; Fahlun, &c.

Colour sky-blue of different shades, commonly deep; streak white.

Sometimes amorphous, but frequently also crystallized. The primary form is a doubly oblique prism.

P on M 127° 30
P on T 108°
M on T 123°



Lustre vitreous.

Semitransparent to translucent.

Rather brittle.

Hardness 2·25; specific gravity 2·213.

Taste metallic and nauseous; soluble in water.

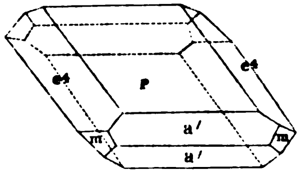
Its constituents are

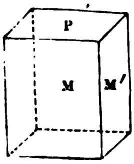
			Atoms.
Sulphuric acid,	32	6·4	1
Oxide of copper,	32	6·4	1
Water,	36	32	5
	100		

It is obviously a hydrous sulphate of copper, composed of
1 atom sulphuric acid,
1 atom oxide of copper,
5 atoms water.

Sp. 4. *Brochantite.*[*]

This name has been given by Mr. Levy to certain small emerald green transparent crystals deposited from malachite, from the Bank mines, in the government of Catherinenburg, Siberia. The crystals are thin rectangular tables bevelled on the edges, and having their angles truncated, as represented in the margin. Mr. Levy has adopted as the primary form a right rhombic prism.





Mr. Children examined a few of these minute crystals by the blowpipe, and found nothing but oxide of copper and sulphuric acid.[†]

The exact constitution and mineralogical description of these crystals must remain unknown, till they be obtained in greater quantity and of a larger size.[‡]

Sp. 5. *Tetrasulphate of Copper.*

This mineral occurs in Mexico, where it is said to be very abundant, but the particular locality is unknown. M. Berthier has analyzed it, but as he has given no description, it is impossible to give its characters.[§] Its gangue is a granular quartz rock. This rock is penetrated with red oxide of copper in a lamellar state, and with tetrasulphate of copper of a verdigris green colour. It has no lustre, has an earthy aspect.

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[*] Named in honour of M. Brochant.

[†] Annals of Philosophy (second series), viii. 241.

[‡] The Königine of Mr. Levy seems to be intimately connected with Brochantite. (See Annals of Philosophy (second series), xi. 194.) Specimens were found in the collection of the Dowager Countess of Aylesford.

Colour emerald green, or greenish black, translucent. Crystals right rhombic prisms, with angles of about 105°. Sometimes the two edges of 105°, or even the 4 edges of the prism, are replaced by tangent planes. These last crystals are barrel-shaped. By Dr. Wollaston's trials the constituents are sulphuric acid and oxide of copper.

[§] Memoires par Berthier, ii. 191.

In general it is intimately mixed with the rock, but sometimes it occurs in grains or small pieces. Berthier found the constituents,

		Atoms.	
Oxide of copper,	45·9	9·18	3·99
Sulphuric acid,	11·5	2·3	1
Water,	12·1	10·75	4·67
Gangue,	30·5		
	100·0		

These numbers correspond with

1 atom sulphuric acid,
4 atoms oxide of copper,
4$\frac{2}{3}$ atoms water.

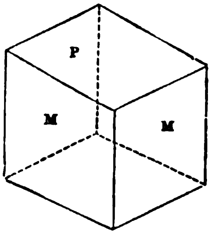
It is therefore a hydrous tetrasulphate of copper.

Sp. 6. *Hydrous Diphosphate of Copper.*

This mineral constitutes a bed in primary rocks at Libethen, near Neusohl, in Hungary.

Colour olive green, generally dark; streak olive green.

Usually in prismatic crystals, often so short as to have an octahedral form. The primary figure, according to Levy, is a right rhombic prism.



M on M′ 95° 20′

Lustre resinous; fracture conchoidal, uneven; no cleavage has been observed.

Translucent on the edges; brittle.

Hardness 4; specific gravity 3·6 to 3·8.

Its constituents, as determined by Berthier,* are as follows:

		Atoms.
Phosphoric acid,	28·7	6·37
Oxide of copper,	63·9	12·78
Water,	7·4	6·57
	100·0	

These numbers correspond with

1 atom phosphoric acid,
2 atoms oxide of copper,
1 atom water.

It is therefore a hydrous diphosphate of copper.

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[*] Ann. des Mines, viii. 334.

Sp. 7. *Pelokonite.*[*]

This mineral is found in the Tierra amarilla and the Remolinos, in China, and has been named and described by M. Richter of Freyberg.[†]

Colour bluish black; streak liver brown.

Never observed in crystals.

Fracture conchoidal.

Opaque.

Lustre vitreous, almost dull.

Brittle, but not remarkably so.

Hardness 3; specific gravity 2·567.

Dissolves easily in muriatic acid, less easily in nitric acid. The muriatic acid solution has a pistachio green colour, and contains iron, manganese, copper and phosphoric acid.

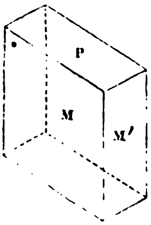
I am not aware that this mineral has been hitherto subjected to a chemical analysis.

Sp. 8. *Hydrous Subbisesquiphosphate of Copper.*

This species is found in veins traversing greywacke slate at Bonn and Virneberg, near Rheinbreitbach, on the Rhine.

Colour emerald green, verdigris green and blackish green, often darker on the surface; streak green, a little paler than that of the mineral.

It has usually a striated structure, arising from a collection of minute crystals aggregated together. The minute and separate crystals are usually dull, and of a blackish-green colour externally. The primary form of the crystal has not been well made out. Mr. Brooke, from imperfect measurements, considers it as an oblique rhombic prism.



P on M or M′ 97° 30′

M on M′ 37° 30′

Fracture small conchoidal, uneven.

Lustre adamantine, inclining to vitreous.

Translucent, at least on the edges.

Hardness 4·75; specific gravity, as determined by Mr. Lunn, 4·2.

Before the blowpipe it readily fuses into a reddish-black slag, adhering to the charcoal, and by the addition of carbonate of soda it is reduced to a bead of pure copper.

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[*] From πελος, *black*, and κονις, *powder*.

[†] Poggendorf's Annalen, xxi. 590.

Its constituents, as determined by Mr. Lunn,* are

			Atoms.
Phosphoric acid,	21·687	4·82	1
Oxide of copper,	62·847	12·569	2·6
Water,	15·454	13·73	2·84
	99·988		

These numbers indicate

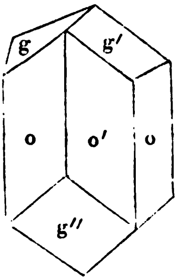
1 atom phosphoric acid,
$2\frac{1}{2}$ atoms copper,
3 atoms water.

It is therefore a *hydrous sub-$2\frac{1}{2}$phosphate of copper.*

Sp. 9. *Hydrous Sesquisilicate of Copper.*

Dioptase—achirite—emerald copper.

This mineral was brought from the Kirghese Steppes by Achir Mehemet, a Bucharian merchant. Hence the origin of the name achirite.



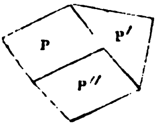
Colour emerald green, also blackish-green, and verdigris green; streak green.

It occurs in crystals, having the form of elongated rhombic dodecahedrons

g on g′ 95° 33′
o′ on o 120° 4′
g on o or g′ on o′ 133°

as measured by Mr. W. Phillips.

The primary form is an obtuse rhomboid P on P′ 126° 17′.



Structure foliated.

Fracture conchoidal, uneven.

Lustre vitreous, inclining to resinous.

Transparent to translucent; brittle.

Hardness 5; specific gravity 5·278.

It decrepitates before the blowpipe, and upon charcoal becomes black in the oxidizing flame, and red in the reducing flame, without melting. Fuses easily with borax, communicating a green colour.

Dissolves without effervescence in nitric acid, and the silica gelatinizes.

Its constituents, as determined by Lowitz,† are

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* Annals of Philosophy (second series), iii. 179.

† *Nova Acta Petropol.* xiii.

		Atoms.	
Silica, .	33 .	16·5 .	1·5
Oxide of copper,	55 .	11 .	1
Water, .	12 .	10·66 .	0·97
	100		

These numbers obviously correspond with

1½ atom silica,
1 atom oxide of copper,
1 atom water.

It is therefore a *hydrous sesquisilicate of copper*.

By the analysis of Hess,[*] its constituents are

		Atoms.	
Oxide of copper,	45·10 .	9·02 .	1
Silica, .	36·85 .	18·42 .	2·04
Water, .	11·52 .	10·32 .	1·14
Alumina, .	2·36		
Lime, .	3·39		
Magnesia, .	0·22		
	99·44		

This analysis leads to a different conclusion from the preceding. It indicates a bisilicate; and dioptase, according to it, differs from the following species only by containing less water.

Sp. 10. *Bisilicate of Copper.*

Kieselmalachite.

This mineral occurs at Somerville, New Jersey, in a copper mine, incrusting the ferruginous copper ore of that mine. It was first described and analyzed by Mr. George T. Bowen. More lately it has been subjected to analysis by M. Berthier.

Colour bluish-green; powder light blue.

Massive.

Fracture conchoidal; opaque; dull.

Easily scratched by the knife.

Specific gravity 2·159.

Alone before the blowpipe it becomes black, and does not melt. With borax it fuses into a glass of a bright green colour. With carbonate of soda gives globules of metallic copper.

Its constituents are as follows:

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[*] Memoires par Berthier, ii. 281.

	*	†	Atoms. 1	2	1	2
Oxide of copper, .	45·175	35·1	9·035	7·02	1	1
Silica, . . .	37·250	35·4	18·625	17·7	2·06	2·52
Oxide of iron and sand,	—	1·0	—	—	—	—
Water, . . .	17·000	28·5	15·11	25·33	1·66	3·6
	99·425	100				

	‡	Atoms.	
Oxide of copper,	40·00	8	1
Silica, .	36·54	18·27	2·28
Oxide of iron,	1·00	—	—
Quartz, .	2·10	—	—
Water, .	20·20	17·95	2·24
	99·84		

This is intermediate between the analyses of Bowen and Berthier.

It is obvious that the two first analyses do not belong to the same species. The first is a bisilicate, composed of

2 atoms silica,
1 atom oxide of copper,
$1\frac{2}{5}$ atom water.

The second is a bisesquisilicate composed of

$2\frac{1}{2}$ atoms silica,
1 atom oxide of copper,
$3\frac{1}{2}$ atoms water.

Berthier has given us a description of the specimen which he analyzed.

Sometimes it constitutes a thin crust of a fine green colour, transparent, having a vitreous lustre, and adhering to the surface of native copper. Sometimes it is in compact masses, having a conchoidal fracture; dull; granular; opaque, or only translucent on the edges; of a sky or blue colour, with a slight shade of green; very soft, and exceedingly light. At first it swims in water, but it gradually absorbs that liquid and then sinks to the bottom, and becomes transparent. Sometimes it is in compact masses, much heavier than the preceding variety, of a pale greenish-blue colour, and pretty hard.

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* Bowen, Silliman's Jour. viii. 118. † Berthier, Memoires par, ii. 257.

‡ *Kobell, Poggendorf's* Annalen, xviii. 254.

This description shows that the mineral analyzed by Berthier cannot be the same with that of Bowen.

Sp. 11. *Hydrous Sub-bisesquiarseniate of Copper.*

Erinite of Haidinger.

This mineral is found in the county of Limerick, in Ireland. The only specimen known existed in Mr. Allan's collection in Edinburgh. It was described by Haidinger, and analyzed by Dr. Turner.*

Colour emerald green, slightly inclining to grass green; streak a pale green, approaching to apple green.

It consists of masses, arranged in concentric coats, with rough surfaces, arising from the termination of exceedingly small crystals. The layers often may be easily separated from each other. They are themselves very compact, show an uneven and sometimes imperfect conchoidal fracture, and traces of cleavage.

These cleavages seem to be parallel to the broad faces of rectangular four-sided plates. These plates form crest-like aggregation.

Lustre almost dull, slightly resinous.

Translucent on the edges.

Hardness 4·75; specific gravity 4·043.

Its constituents, as determined by the analysis of Dr. Turner, are

		Atoms.	
Oxide of copper,	59·44	11·89	2·55
Alumina,	1·77	0·78	0·16
Arsenic acid,	33·78	4·66	1
Water,	5·01	4·45	0·95
	100·00		

These numbers (leaving out the alumina) correspond with

1 atom arsenic acid,
2½ atoms oxide of copper,
1 atom water.

The mineral is therefore a hydrous subbisesquiarseniate of copper.

Sp. 12. *Copper Schaum.*

Kupferschaum—bardiglione—pharmacosiderite.

This mineral occurs at Schwatz, in the Tyrol, in the Bannat of Temeswar, at Matlock in Derbyshire, and perhaps in other localities.

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* Phil. Magazine (second series), iv. 154.

Colour pale apple green, and verdigris green, inclining to sky blue; streak of the same colour, but paler.

Massive and crystallized in octahedrons; structure radiated or foliated.

Very sectile; thin laminæ flexible.

Lustre pearly upon one of the faces, vitreous on the others.

Translucent on the edges.

Hardness 1·25; specific gravity 3·098.

It occurs in beds and veins accompanied by other ores of copper, especially *blue* copper ore.

Its constituents, determined by the analysis of Kobell,* are as follows:—

		Atoms.	
Arsenic acid,	25·01	3·45	1
Oxide of copper,	43·88	8·77	2·54
Water,	17·46	15·52	4·5
Carbonate of lime,	13·65	2·18	0·63
	100·00		

If the carbonate of lime be a foreign substance, as is most likely, the constitution of this mineral is

1 atom arsenic acid,
2½ atoms oxide of copper,
4½ atoms water.

It is therefore a *hydrous subbisesquiarseniate of copper*. It differs from the preceding species merely by containing more water.

Sp. 13. *Diarseniate of Copper.*

Euchroite—emerald malachite.

This mineral was discovered at Libethen, in Hungary, in quartzose mica slate, and brought to London under the name of euchroite. It was first described by Haidinger, and analyzed by Dr. Turner.†

Colour bright emerald green; streak apple green.

Occurs crystallized in four-sided prisms, with angles of 117° 20′.

Cleavage indistinct.

Fracture small conchoidal, uneven.

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* Poggendorf's Annalen, xviii. 253.

† *Schweigger's* Jahrbuch, xv. 231, 233.

Lustre vitreous.

Transparent to translucent.

Refracts doubly, pretty strongly.

Rather brittle.

Hardness 3·75; specific gravity 3·389.

When heated it loses water, and becomes yellowish-green and friable. When heated to a certain point upon charcoal, it is reduced in an instant with a kind of deflagration, leaving a globule of malleable copper, with white metallic particles dispersed through it, which are entirely volatilized if the heat be continued.

Its constituents, as determined by the analysis of Dr. Turner, are as follows:

			Atoms.
Arsenic acid,	33·02	4·55	1
Oxide of copper,	47·85	9·57	2·10
Water,	18·80	16·71	3·67
	99·67		

These numbers correspond with

1 atom arsenic acid,
2 atoms oxide of copper,
$3\frac{2}{3}$ atoms water.

It is therefore a hydrous diarseniate of copper.

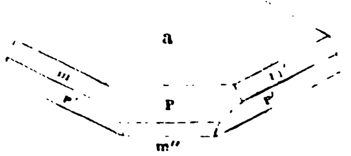
Sp. 14. *Copper Mica.*

Foliated oliven ore. Kupfer glimmer. Hexahedral arseniate of Bournon.

The localities of this species are the same as of the two succeeding ores.

Colour emerald green, grass green; streak emerald green, apple green, rather paler.

Occurs in six-sided tabular crystals, as represented in the margin.



P on a 108° 40′
P on P′ or P″ 110° 30′
P′ or P″ on a 128° 18′
a on m or m′ 124° 42′

The primary form is an acute rhomboid, of which the faces P, P′, P″ in the figure are in their relative position, and exhibit the angles.

Cleavage most perfect, perpendicular to the axis of the rhomboid; that is, parallel to the face a of the hexagonal table.

Fracture conchoidal, but scarcely observable.

Lustre of the flat faces of the hexagonal table pearly, of the other faces vitreous.

Transparent to translucent; sectile.

Hardness 2; specific gravity, as determined by Bournon, 2·5488.

It decrepitates before the blowpipe, is transformed into a black spongy scoria, and then melts into a black globule, having sometimes no vitreous appearance. Its constituents, as determined by Mr. Brooke, are

1 atom arsenic acid,
2 atoms oxide of copper,
3 atoms water.

It is a *terhydrous diarseniate of copper*, and probably is not specifically distinct from euchroite.

Sp. 15. *Prismatic Oliven Ore. Olivenite.*

Prismatic arseniate of Bournon.

This mineral occurs in several of the copper mines in the neighbourhood of Redruth, at Tingtang, Huel Garland, Huel Unity, &c. It was first described by Bournon, and analyzed by Chenevix, in 1801.

Colour various shades of olive green, passing into leek green, pistachio green, and blackish green; into liver brown, and wood brown, or also into siskin green; streak olive green, or even brown.

It occurs in fine capillary flexible threads, and in small prismatic crystals, which are mechanically divisible parallel to the planes of a right rhombic prism of 111° 45′, as measured by Brooke,* or 110° 50′ according to Phillips. Most commonly it occurs in a rhombic prism of 84° and 96°, terminated by a dihedral apex with isosceles triangular faces inclined to each other, at an angle of 112°, and rising from the acute angle of the prism.

Fracture, when visible, conchoidal, uneven.

Lustre between vitreous and resinous.

Semitransparent to opaque; brittle.

Hardness 3; specific gravity, as determined by Bournon, 4·2809; as determined by Mr. Richardson, 4·166.

Alone it remains unchanged before the blowpipe. On charcoal it melts with a kind of deflagration, and is reduced. A white metallic globule is formed, which in the process of cooling becomes coated with red oxide of copper.

* Edin. Jour. vi. 133.

Soluble in nitric acid.

We have various analyses of this ore by Chenevix, but his methods of analysis were not of a nature to procure accurate results. Mr. Brooke* informs us that he found the constituents

1 atom arsenic acid,
2 atoms oxide of copper,
$1\frac{1}{2}$ atom water.

Kobell analyzed it in 1830,† and obtained

		Atoms.
Arsenic acid,	36·71	5·06
Phosphoric acid,	3·36	0·74
Oxide of copper,	56·43	11·28
Water,	3·50	3·11
	100·00	

The analysis of it by Mr. Richardson, in my laboratory, agrees very nearly with that of Kobell. He obtained

Arsenic acid,	39·9	1
Oxide of copper,	56·2	2·04
Water,	3·9	0·63
	100	

It is obvious from this, that it is an anhydrous diarseniate of copper; or the water, at least if an essential constituent, does not exceed half an atom.

Sp. 16. *Acicular Oliven Ore.*

Trihedral arseniate of Bournon—trihedral oliven ore—oblique prismatic arseniate of copper.

This species occurs in Cornwall, in the same localities as the preceding species.

Colour dark verdigris green, inclining to sky blue; still darker on the surface; streak pea green.

Occurs, though rarely, in very minute crystals, which may easily be mistaken for acute rhomboids, of which the acute terminations are sometimes replaced by triangular planes; but they are in fact oblique rhombic prisms, the lateral planes of which meet at angles of 56° and 124°. The inclination of the summit of the prism on the lateral planes is 95°, according to the measurement of Mr. Brooke.

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* Edin. Jour. p. 134.

† Poggendorf's Annalen, xviii. 249.

Lustre pearly on the face of perfect cleavage, on other faces resinous; translucent on the edges. Not very brittle.

Hardness 2·75. Specific gravity, by Bournon, 4·192; as determined by Mr. Richardson, 4·048.

Deflagrates before the blowpipe, and gives out arsenical vapours.

According to Mr. Brooke, its constituents are

1 atom arsenic acid,
2 atoms oxide of copper,
2 atoms water.

But it was carefully analyzed by Mr. Richardson in my laboratory, who found its constituents

		Atoms.
Arsenic acid,	39·80 .	1
Oxide of copper,	56·65 .	2·06
Water, .	3·55 .	0·57
	100	

It is therefore identical in its composition with prismatic oliven ore, being, like it, an anhydrous diarseniate of copper.

Sp. 17. *Amianthiform Diarseniate of Copper.*

A variety of Bournon's acute octahedral arseniate.

Colour light olive-green, of different shades.

Composed of a congeries of imperfect spheres, consisting each of capillary flexible threads diverging from a centre. The length of these threads varies from ¼ to ½ inch.

Soft enough to be scratched by the nail.

Opaque; sectile; specific gravity 4·2697.

The action of the blowpipe being nearly the same on all the varieties of arseniated copper, we may refer to pages 612 and 613 of this volume.

I subjected it to analysis, and obtained

		Atoms.
Arsenic acid, .	40·61 .	1
Oxide of copper,	54·98 .	1·96
Water, . . .	4·41 .	0·7
	100·00	

It is obviously an anhydrous diarseniate, similar in its composition with the two preceding species.

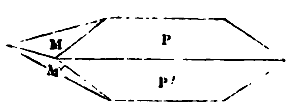
Sp. 18. *Octahedral Arseniate of Copper.*

Linsenerz, lenticular copper ore, prismatic liriconite.

This species has been hitherto found only in veins in the following Cornish mines, Huel Muttrel, Huel Garland, Huel Unity, where it is associated with the three preceding species.

Colour bluish-white, bluish-green, sky-blue, greenish-white and deep grass-green; streak similar, very pale.

The primary form of the crystal is considered to be an obtuse octahedron, in which the common base of the two pyramids is rectangular. This octahedron is usually elongated, as represented in the margin.



M on P or M′ on P′ 133° 30′
P on P′ 60° 40′
M on M′ 72° 22′

Mr. Brooke suspects the primary form to be an oblique rhombic prism.*

Fracture imperfect conchoidal, uneven.

Lustre vitreous, inclining to resinous.

Semitransparent to translucent; nearly sectile.

Hardness 2·25; specific gravity, as determined by Bournon, 2·882; according to Haidinger 2·926. I found it 2·78, but the specimen was impure.

Before the blowpipe it loses its transparency and colour, emits fumes of arsenic, and is changed into a friable scoria, containing some metallic globules. With borax gives a green glass, and is partly reduced.

According to the analysis of Mr. Brooke, its constituents are

1 atom arsenic acid,
1 atom oxide of copper,
5 atoms water.

I picked out 4·215 grains of pure crystals of this mineral, and subjected them to analysis. The analysis could not be very satisfactory, on account of the small quantity employed. But the result was as follows:

		Atoms.
Arsenic acid,	43·39	1
Oxide of copper,	30·10	1·007
Water,	26·69	3·966
	00·18	

This is obviously a compound of

---

* Edin. Jour. vi. 132.

1 atom arsenic acid,
1 atom oxide of copper,
4 atoms water.

It is therefore a hydrous arseniate of copper.*

The species of arseniated copper, in a chemical point of view, may be reduced to 7:—

1. Hydrous subbisesquiarseniate of copper, composed of
    1 atom arsenic acid,
    2½ atoms oxide of copper,
    1 atom water.
2. Copper schaum, composed of
    1 atom arsenic acid,
    2½ atoms oxide of copper,
    4½ atoms water.
3. Copper mica, composed of
    1 atom arsenic acid,
    2 atoms oxide of copper,
    3 atoms water.
4. Euchroite, composed of
    1 atom arsenic acid,
    2 atoms oxide of copper,
    3⅔ atoms water.
5. Linsenerz of Trollé Wáchmeister, composed of
    1 atom arsenic acid,
    2 atoms oxide of copper,
    5⅔ atoms water.

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* Trollé Wachmeister published in the Memoirs of the Stockholm Academy, for 1832, an analysis of the blue Linsenerz from Cornwall. He gives no description of the mineral which he examined, but it is evident from the result of his analysis that his mineral belonged to a different species from the mineral described in the text. He obtained*

		Atoms.	
Water,	22·24	5·65	
Oxide of copper,	35·19	2	
Alumina,	8·03	—	
Peroxide of iron,	3·41	—	
Arsenic acid,	20·79	0·81	1·03
Phosphoric acid,	3·61	0·22	
Silica,	4·04		
Sand,	2·95		
	100·26		

The specimen was obviously very impure, but if we take the phosphoric acid along with the arsenic, the species is obviously a diarseniate of copper united with between 5 and 6 atoms water.

* *Poggendorf's* Annalen, xxv. 305.

6. Anhydrous diarseniate of copper, composed of
1 atom arsenic acid,
2 atoms oxide of copper,
$\frac{1}{2}$ atom water.

It includes species 15, 16 and 17.

7. Hydrous arseniate of copper, composed of
1 atom arsenic acid,
1 atom oxide of copper,
4 atoms water.

The constitution of these minerals will be better seen if we represent it in symbols.

1. $\underset{\cdot}{C}p^{2\frac{1}{2}}\dot{A}s+Aq$.
2. $\underset{\cdot}{C}p^{2\frac{1}{2}}\dot{A}s+4\frac{1}{2}Aq$.
3. $\underset{\cdot}{C}p^{2}\dot{A}s+3Aq$.
4. $\underset{\cdot}{C}p^{2}\dot{A}s+3\frac{2}{5}Aq$.
5. $\underset{\cdot}{C}p^{2}\dot{A}s+5\frac{2}{5}Aq$.
6. $\underset{\cdot}{C}p^{2}\dot{A}s+\frac{1}{2}Aq$.
7. $\underset{\cdot}{C}p\dot{A}s+4Aq$.

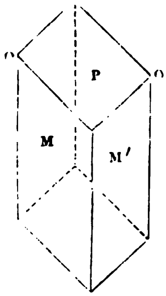
3. *Double Oxygen Salts of Copper.*

Sp. 1. *Hydro-Carbonate of Copper.*

Blue copper ore.

This species is met with in the same localities as malachite, or *hydrous carbonate of copper.*

Colour various shades of azure blue, passing into blackish-blue and Berlin-blue; streak similar, but lighter.



Massive and crystallized. By mechanical division an oblique rhombic prism may be obtained, which constitutes the primary form.

P on M or M′ 91° 30′
M on M′ 98° 50′

The terminal edges of the prism are frequently replaced by planes, which, if sufficiently enlarged, would constitute a four-sided pyramid. Sometimes the obtuse lateral edges of the prism are replaced by planes, and sometimes the angles o are replaced by triangular planes.

Texture foliated; fracture conchoidal.

Lustre vitreous, almost adamantine.

Transparent to translucent on the edges.

Brittle.

Hardness 4·25; specific gravity 3·831.

When heated it becomes black. It melts before the blowpipe on charcoal, and colours borax green in the oxidizing flame.

Dissolves with effervescence in nitric acid.

Its constituents are as follows:

	*	†	‡	Atoms.	
Carbonic acid,	24	21·25	25·76	9·36	1·93
Oxide of copper,	70	70	69·08	13·81	2·84
Water, .	6	8·75	5·46	4·85	1
	100	100	100·30		

Taking Phillips' result as probably the most accurate, the constituents are

2 atoms carbonic acid,
3 atoms oxide of copper,
1 atom water.

Hence the constitution of the mineral must be

2 atoms carbonate of copper,
1 atom hydrate of copper.

It is therefore a hydro-carbonate of copper. To the presence of water it is indebted for its blue colour.

Sp. 2. *Silico-Carbonate of Copper.*

Chrysocolla, copper green, kieselmalachite?

This species occurs along with other copper ores in Thuringia, the Hartz, Hungary, Cornwall, Norway, Siberia, Mexico, Chili, &c.

Colour emerald green, pistachio green, asparagus green, passing into sky blue; streak white, a little shining.

Texture compact without any cleavage.

Fracture conchoidal.

Lustre vitreous and very various in intensity.

Semitransparent to translucent on the edges; rather sectile.

Hardness 3; specific gravity 2·238.

Before the blowpipe on charcoal it becomes black in the interior flame without melting. With borax it melts into a green glassy globule, and is partly reduced.

When in lumps it dissolves without sensible effervescence in nitric acid; but it effervesces when in powder.

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* Klaproth, Beitrage, iv. 31.

† Vauquelin, Ann. de Museum, xx. 1.

‡ Phillips, Royal Institution Jour. iv. 276.

Its constituents are as follows :—

	*	†	‡	Atoms.	
Silica, . .	26	28·37	25·31	12·65	2·32
Carbonic acid, .	7	3·00	14·98	5·44	1
Oxide of copper, .	50	49·63	54·46	10·89	2
Water, . .	17	17·50	5·25	4·66	0·84
Sulphate of lime, .	—	1·50	—		
	100	100	100		

The great difference in the proportion of carbonic acid in these analyses, renders it probable that the carbonate and silicate of copper are not chemically combined, but only mechanically mixed. Yet the specimen which I analyzed appeared, even under a strong magnifier, perfectly homogeneous.

The atomic numbers, determined from my analysis, approach

2 atoms silica,
1 atom carbonic acid,
2 atoms oxide of copper,
1 atom water.

Hence the constitution of the mineral seems to be

1 atom carbonate of copper,
1 atom bisilicate of copper,
1 atom water.

4. *Chlorine Salts of Copper.*

Sp. 1. *Hexmuriate of Copper.*

Greensand of Peru—atacamite.

This mineral was first brought to Europe by Dombey, and was supposed to occur in the state of sand in the desert of Atacama, separating Chili from Peru. But M. Mariano de Rivero informs us that it occurs in veins in the district of Tarapaca; that the Indians of Atacama extract it from these veins, reduce it to powder, and pass it through a sierce. In this state they give it the name of arenillo, and sell it all over Chili as a powder for letters.§ It is said to occur also at

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* Klaproth, Beitrage, iv. 34. † John.

‡ By my analysis. Annals of Philosophy, vii. 322.

§ Ann. de Chim. et de Phys. xviii. 442.

Remolinos, in Chili, in brown ironstone. It has been observed investing some of the lavas from Mount Vesuvius, and at Schwartzenberg, in Saxony.

Colour olive, leek, emerald, and blackish-green; streak apple-green.

It occurs in minute crystals, of which the primary form is a right rhombic prism.

M on M′ 97° 20′

One of the most common crystals is an octahedron with a rectangular base.

Cleavage parallel to the base of the primary prism perfect. Less distinct parallel to the lateral faces of the prism.

Lustre adamantine.

Semitransparent to translucent on the edges; rather brittle.

Hardness 2·5; specific gravity 4·43.

Communicates bright blue and green colours to the flame of a candle. Before the blowpipe gives out fumes of muriatic acid, and melts at last into a globule of copper.

Dissolves without effervescence in nitric acid.

Its constituents are as follows:—

	*	*	†	Atoms.	
Muriatic acid, .	10·6	11·4	10·1	2·18	1
Oxide of copper, .	76·6	70·5	73	14·6	6·7
Water, . .	12·8	18·1	16·9	15	6·88
	100	100	100		

The atomic numbers derived from Klaproth's analysis, are

1 atom muriatic acid,
6¾ atoms oxide of copper,
7 atoms water.

But Proust's analyses rather lead to the conclusion that it is composed of

1 atom muriatic acid,
6 atoms oxide of copper,
6 atoms water.

It seems therefore to be a *hydrous hexmuriate of copper.*

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* Proust, Ann. de Chim. xxxii. 49.

† Klaproth, Beitrage, iii. 200.

5. *Sulphur Salts of Copper.*

Sp. 1. *Variegated Copper Ore.*

Buntkupfererz—liver-coloured copper ore.

This species occurs both in primary and secondary formations, and is associated with other ores of copper. In Cornwall it has been observed in Cookskitchen, Tincroft, and Dolcoath, and in several other mines in the same county. In the Bannat, and at Mansfield it is found in beds. Ireland, Silesia, Norway, Sweden, Greenland, may also be mentioned as countries where it is found, though only in small quantities.

Colour intermediate between copper-red, and pinchbeck brown; streak pale greyish black, a little shining.

Occurs both massive and crystallized. The usual form is the cube, with the solid angles replaced by triangular planes.

Cleaves parallel to these triangular faces. Hence its primary form is the regular octahedron.

Lustre metallic; liable to tarnish, and then is iridescent; rather sectile; opaque.

Hardness 2·5; specific gravity 5·003.

Before the blowpipe it behaves almost like *copper pyrites.*

Its constituents are

	*	†	Atoms.
Copper,	63·334	61·07	15·55
Iron,	11·804	14·00	3·68
Sulphur,	24·696	23·75	12·11
Silica,	0·166	0·50	
	100	99·32	

The third column gives the mean atomic numbers deduced from both analyses. They approach pretty nearly to

4 atoms copper,
1 atom iron,
3 atoms sulphur.

The constitution of the mineral then is

2 atoms disulphuret of copper,
1 atom sulphuret of iron.

Probably the first of these sulphurets acts the part of an acid

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[*] Hisinger, Afhandlingar, iv. 359.

[†] R. Phillips, Annals of Philosophy (second series), iii. 81.

and the second of a base. It may then be considered as a *bisulphocuprite of iron.*

Sp. 2. *Copper Pyrites.*

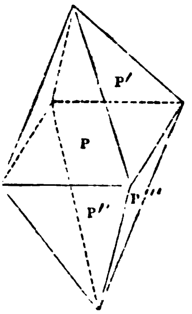
Yellow copper ore.

This is one of the most abundant and important ores of copper; a very great proportion of the copper of commerce being extracted from it. It occurs both in veins and beds. In veins it is very abundant in Cornwall, and the celebrated Parys mountain in Anglesea doubtless constituted a bed. It is found also in veins in Saxony and the Hartz. Many other localities are well known, as Fahlun, Siberia, Norway, &c.

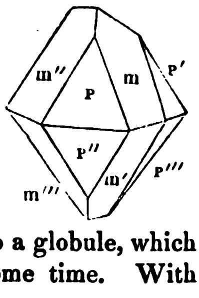
Colour brass yellow; streak greenish-black, a little shining.

It occurs both massive and in crystals. The usual shape of the crystal is a tetrahedron, with the angles replaced by small triangular planes. But Mr. Phillips has shown that the primary crystal is an octahedron with a square base.

P on P′ or P″ on P‴ 101° 52′
'P on P″ or P′ on P‴ 126° 30′



The edges of the pyramids, but not their common base, are often replaced by faces m, m′, m″, &c. When these become so large as to obliterate the faces P, P′, &c., the tetrahedron with its angles truncated is formed, which is the common shape of the crystal.



Fracture uneven.

Lustre metallic; opaque; rather sectile.

Hardness 2·75; specific gravity from 4·159 to 4·160.

On charcoal it becomes black before the blowpipe, and red on cooling. It melts into a globule, which becomes magnetic if kept in the blast for some time. With borax it yields a globule of copper.

Dissolves in dilute nitric acid, leaving sulphur. The solution is green, and contains copper and iron.

Its constituents are as follows:

	*	†	‡	‡	§	‖	¶
Sulphur, . .	36·5	34·46	35·87	36·52	36·33	32	36·3
Copper, . .	30·0	31·20	34·40	33·12	32·30	32·6	32·1
Iron, . . .	31·0	30·80	30·47	30·00	30·03	29·2	31·5
Earthy matter,	1·0	1·10	0·27	0·39	2·23	3·2	—
Zinc, . . .	1·0	—	—	—	—	—	—
	99·5	97·56	101·01	100·08	100·79	97·0	99·9

	‖	‖	¶	¶	**
Sulphur, . . .	32	33·6	33·841	35·01	34·655
Copper, . . .	33·3	31·2	31·006	32·95	33·640
Iron, ...	30·0	32·2	35·630	32·04	31·535
Earthy matter, .	2·6	1·6	—	—	0·555
	97·9	98·6	100·477	100	100·385

These analyses do not differ much from each other. The analysts do not seem always to have succeeded in separating the copper completely from the iron. Abstracting the impurities, it is obvious that copper pyrites is composed of

2 atoms sulphur,
1 atom copper,
1 atom iron.

It is therefore a compound of

1 atom sulphuret of copper, probably acting the part of an acid.

1 atom sulphuret of iron, acting the part of a base.

It is a *sulphocuprate of iron.*

Sp. 3. *Bournonite.*

Endellione—triple sulphuret.

This mineral was first observed in Huel Boys, in the parish of Endellion, Cornwall. It has only been observed in veins. It was next met with at Kapnick in Transylvania; afterwards

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[*] Gueniveau; Nicholson's Jour. xxi. 145.

[†] Phillips, Annals of Philosophy (2d series), iii. 299.

[‡] H. Rose, ibid. vii. 355. The first specimen was from Ramberg, the second from Furstenberg.

[§] Hartwell of Abo. Ibid. p. 155.

[‖] Berthier, Ann. des Mines, viii. 341.

[¶] By my analysis. The specimens were from Anglesea.

[**] By my analysis. A fine crystal from the United Mines, Cornwall. Specific gravity 4·160.

in Auvergne. Magnificent crystals of it were found at Neudorf in Anhalt, and at Andreasberg in the Hartz.

Colour steel-grey, inclining to blackish lead-grey or iron-black, according to the physical qualities of the surface; streak unaltered.

It occurs partly crystallized in the form of rectangular prisms, variously modified, and partly imbedded. It is perfectly lamellar, affording brilliant planes by mechanical division, parallel to the lateral planes of a right rectangular prism, and likewise to both the diagonals of the base of the prism. Thus the primary form may be either a right rectangular or a right rhombic prism, with angles of 93° 30′, and 86° 30′. But the first of these figures has been preferred by crystallographers. The secondary forms are produced by planes upon the edges and angles of this primary form.

Lustre metallic; opaque; brittle.

Hardness 2·75; specific gravity, as determined by Hatchett, 5·766.

Before the blowpipe upon charcoal, it melts, smokes, and yields a black globule. In a strong heat the charcoal becomes covered with a globule of lead.

Dissolves easily in nitric acid when assisted by heat.

Its constituents are

	*	†	‡	§
Sulphur, . . .	17	18	13·50	16
Antimony, . . .	24·35	19·75	16·00	28·5
Lead, ...	41·12	42·52	34·50	39
Copper, . . .	12·80	11·75	16·25	13·5
Iron, ...	1·20	5·00	13·75	1
Silver, ...	—	—	2·25	—
Lime and silica, . .	—	—	2·5	—
	96·47	97·00	98·75	98·0

The third of these specimens was obviously impure. This seems to be the case with the fourth also; at least it contains much more antimony than any of the others. The mean of the first two analyses gives us

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[*] Hatchett, Nicholson's Jour. ix. 16. Correcting some of his estimates.

[†] Klaproth, Gehlen's Jour. v. 34. Specimen from Altensegen in Clausthal.

[‡] Klaproth, Beitrage, iv. 86. From Andreasberg.

[§] *Klaproth, ibid. p. 87.* From Nanslo in Cornwall.

			Atoms.
Sulphur,	17·5	8·75	2·72
Antimony,	22·05	5·26	1·64
Lead,	41·81	3·21	1
Copper,	12·27	3·07	0·95
Iron,	3·10	0·88	0·27

These numbers approach nearly to

5½ atoms sulphur,
3 atoms antimony,
2 atoms lead,
2 atoms copper.

But M. H. Rose* has lately subjected this mineral to a careful analysis, and obtained the following constituents from crystals from Pfaffenberg, near Neudorf.

			Atoms.
Sulphur,	20·31	10·15	3·21
Antimony,	26·28	3·28	1·03
Lead,	40·84	3·14	0·99
Copper,	12·65	3·16	1
	100·08		

These numbers are obviously

3 atoms sulphur,
1 atom antimony,
1 atom lead,
1 atom copper.

Hence the mineral must be composed of

1 atom sulphide of antimony,
1 atom sulphuret of lead,
1 atom sulphuret of copper.

The first of these acts the part of an acid, and the other two of bases. Bournonite is a compound of

1 atom disulpho-antimonite of lead,
1 atom disulpho-antimonite of copper.

Sp. 4. *Grey Copper Ore.*

Fahlerz—fahl ore.

This mineral occurs along with the other species. There is some risk in pointing out localities, because various species have been certainly confounded together under the name of grey copper ore.

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* Poggendorf's Annalen, xv. 573.

Colour steel-grey, or iron-black; streak unaltered, sometimes inclining to brown.

Massive and crystallized in tetrahedrons, which is considered the primary form. But no regular structure is visible. Nor have the crystals been sufficiently examined to detect their true form.

Lustre metallic; opaque; rather brittle.

Hardness 2·75; specific gravity, as determined by Haidinger, from 4·798 to 5·104.

To determine the chemical constitution of this difficult species, M. H. Rose has analyzed seven carefully selected and pure crystallized specimens from different localities.* These analyses having thrown a new light on the subject, it will be requisite to state the results here.

1. Grey copper ore from St. Marie aux Mines, in Alsace. It is accompanied by quartz and grey oxide of manganese; streak black.

		Atoms.
Sulphur,	26·83	13·41
Antimony,	12·46	1·59
Arsenic,	10·19	2·14
Iron,	4·66	1·33
Zinc,	3·69	0·86
Silver,	0·60	0·04
Copper,	40·60	10·15
Quartz,	0·41	
	99·44	

The atoms of antimony, arsenic, and copper, are 13·88, and those of sulphur 13·41. Hence these metals must be in the state of simple sulphurets.

The atoms of antimony and arsenic are nearly $\frac{1}{3}$ of those of copper. Hence the essential constituents of this specimen seem to be

$$1 \text{ atom sulphide of} \left\{\begin{array}{l}\text{antimony,}\\ \text{arsenic,}\end{array}\right.$$

3 atoms sulphuret of copper.

$$\text{The mineral is a trisulpho-}\left\{\begin{array}{l}\text{antimonite}\\ \text{arsenite}\end{array}\right\} \text{ of copper.}$$

2. From Gersdorf, by Freyberg. It occurs in veins in gneiss, with crystallized fluor spar and sulphate of barytes. Streak black.

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* Poggendorf's Annalen, xv. 576.

		Atoms.
Sulphur,	26·33	13·16
Antimony,	16·52	2·06
Arsenic,	7·21	1·5
Iron,	4·89	1·39
Zinc,	2·76	0·64
Silver,	2·37	0·17
Copper,	38·63	9·76
	98·71	

Here, to make the atoms of the copper thrice the number of those of antimony and arsenic, we must add the atoms of zinc and silver. This specimen, like the last, consists of

1 atom sulphide of $\begin{cases}\text{antimony,}\\ \text{arsenic,}\end{cases}$
3 atoms sulphuret of copper, silver, zinc.

But the antimony bears a much greater proportion to the arsenic than in the first specimen.

3. From Kapnick in Hungary. It occurs in fine crystals along with crystallized quartz, galena, iron pyrites, and yellow blende; streak dark red.

		Atoms.
Sulphur,	25·77	12·88
Antimony,	23·94	2·99
Arsenic,	2·88	0·60
Iron,	0·86	0·24
Zinc,	7·29	1·71
Silver,	0·62	0·04
Copper,	37·98	9·49
	99·34	

To make the atoms of copper thrice those of the antimony and arsenic, it will be necessary to add to them a little of the zinc, but not the whole.

This specimen, like the preceding, consists of

1 atom sulphide of $\begin{cases}\text{antimony,}\\ \text{arsenic,}\end{cases}$
3 atoms sulphuret of copper.

But the antimony exists in 5 times as many atoms as the arsenic.

4. From Dillenburg. It occurs in veins in greywacke; streak cherry-red. Crystals frequently mixed with iron pyrites.

		Atoms.
Sulphur,	25·03	12·51
Antimony,	25·27	3·16
Arsenic,	2·26	0·47
Iron,	1·52	0·43
Zinc,	6·85	1·58
Silver,	0·83	0·06
Copper,	38·42	9·60
	100·18	

This is obviously similar to the others, consisting of

1 atom sulphide of $\left\{\begin{array}{l}\text{antimony,}\\ \text{arsenic,}\end{array}\right.$

3 atoms sulphuret of copper.

5. From Zilla, near Clausthal. It is crystallized in tetrahedrons, usually incrusted with copper pyrites. It occurs in veins in greywacke along with galena, sparry iron ore and brown spar; streak dark red.

		Atoms.
Sulphur,	24·73	12·36
Antimony,	28·24	3·53
Iron,	2·27	0·64
Zinc,	5·55	1·30
Silver,	4·97	0·36
Copper,	34·48	8·62
	100·24	

Here there is no arsenic at all. To make the atoms of copper thrice those of antimony, we must add the zinc and silver. The specimen is composed of

1 atom sulphide of antimony,
3 atoms sulphuret of copper.

6. From the Wenzel mine, near Walfort in Furstenberg. It occurs in veins in talky gneiss, with crystals of sulphate of barytes and some galena; streak black.

		Atoms.
Sulphur,	23·52	11·76
Antimony,	26·63	3·33
Iron,	3·72	1·06
Zinc,	3·10	0·72
Silver,	17·71	1·28
Copper,	25·23	6·31
	99·91	

Here, to make the atoms of copper thrice those of antimony, we must add all the other metals. The specimen consists of

1 atom sulphide of antimony,

$$3 \text{ atoms sulphuret of} \begin{cases} \text{copper}, \quad . & 2 \\ \text{silver, zinc, iron}, & 1 \end{cases}$$

7. *From Habacht-Fund mine, near Freyberg.* This mineral at Freyberg is called crystallized Weissgültigerz. But its composition is quite different from the Weissgültigerz of Freyberg analyzed by Klaproth. It is crystallized in tetrahedrons, and occurs along with galena, copper pyrites, rothgüld, brown spar, grey oxide of manganese, blende, and quartz.

		Atoms.
Sulphur,	21·17	10·58
Antimony,	24·63	3·08
Iron,	5·98	1·7
Zinc,	0·99	0·23
Silver,	31·29	2·27
Copper,	14·81	3·70
	98·87	

Here the whole metals taken together, do not amount to three times the number of atoms of the antimony. I suspect the reason to be, that the atom of silver is reckoned twice as heavy as it ought to be. If that supposition be allowed, this specimen like the rest, will consist of

1 atom sulphide of antimony,
3 atoms sulphuret of copper, silver, and iron.

From the preceding analyses, grey copper ore appears to consist essentially of

1 atom sulphide of antimony,
3 atoms sulphuret of copper,

united together. The antimony is sometimes partly replaced by arsenic; and the copper, by silver, iron, and even zinc; but the pure mineral is a *trisulpho-antimonite of copper.*

Sp. 5. *Tennantite.*[*]

This mineral occurs in veins in several of the Cornish copper mines, as Dolcoath, Cookskitchen, and Tincroft, near Redruth; and in Huel Virgin, Huel Jewel, and Huel Unity, near St. Day. It was first described as a peculiar species by Mr. Phillips.

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[*] Quarterly Jour. vii. 95. Named in honour of Mr. Smithson Tennant.

Colour blackish lead-grey; streak reddish-grey.

Occurs crystallized in cubes, octahedrons, and rhomboidal dodecahedrons. Mr. Phillips considers the regular octahedron as the primary form; but Mr. Brooke thinks that the tetrahedron agrees better with some of the secondary modifications.

Lustre metallic; opaque; brittle.

Hardness 3; specific gravity, as determined by Mr. Richard Phillips, 4·375.

Before the blowpipe it decrepitates a little and burns with a blue flame, emitting copious arsenical vapours, and melting into a black scoria, which affects the magnetic needle.

Its constituents, as determined by Mr. R. Phillips, are

		Atoms.
Sulphur,	28·74	14·37
Arsenic,	11·84	2·49
Copper,	45·32	11·33
Iron,	9·26	2·64
Silica,	5·00	2·5
	100·16*	

The sulphur is combined with the arsenic and copper, converting them respectively into sulphurets, while the iron (doubtless in the state of oxide) is united to the silica. If we admit the silicate of iron to be a foreign body, Tennantite will consist of

1 atom sulphide of arsenic,
4½ atoms sulphuret of copper.

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* Mr. Hemming has given the analysis of a specimen of Tennantite from Trevisane mine, in the parish of Gwennap.† He obtained

		Atoms.	
Sulphur,	21·8	10·9	4½
Arsenic,	11·5	2·42	1
Copper,	48·4	12·1	5
Iron,	14·2	4·0	1·65
Silica,	5·0	2·5	
	100·9		

If this analysis be correct, the mineral examined constitutes a new species, the constituents of which are

1 atom subsesquisulphide of arsenic,
5 atoms subsesquisulphuret of copper,
1⅔ atoms subsesquisulphuret of iron.

Unless we were to consider the iron as united to the silica, as in the specimen examined by Mr. Phillips.

† Phil. Mag. x. 157.

It is therefore a *sulphur salt*, the sulphide of arsenic acting the part of an acid, and the sulphuret of copper as a base.

6. *Selenium Salts of Copper.*

Sp. 1. *Eukairite.*[*]

Argentiferous seleniet of copper.

This mineral was detected by Berzelius in the Swedish geographical collection of minerals among the specimens from Skrickerum, an abandoned mine in Smoland.[†]

Colour lead grey.

Lustre metallic; opaque.

Not crystallized.

Soft enough to be scratched by the knife, and it acquires a silvery lustre.

Takes an impression from the hammer.

Melts easily before the blowpipe, giving out a strong vapour of selenium, and leaves a lead-grey globule, from which the selenium has not been fully expelled. If this globule be melted with borax, it communicates the usual colour of copper, and a grey brittle metallic globule of seleniet of silver remains behind.

When it is dissolved in boiling nitric acid, and the solution is afterwards diluted with water, a white powder precipitates, which is seleniate of silver.

Its constituents, as determined by Berzelius, are

			Atoms.
Selenium,	26	5·2	1·84
Copper,	23·05	5·61	1·98
Silver,	38·93	2·83	1
Foreign earthy matter,	8·90		
	96·88		

These numbers correspond with

2 atoms selenium,
2 atoms copper,
1 atom silver.

Hence the constitution of the mineral is

2 atoms diseleniet of copper,
1 atom seleniet of silver.

---

[*] From ἐυ and καιϱος, *opportunity*, so named because the mineral was found soon after the discovery of selenium.

[†] Afhandlingar, vi. 136.

Probably the first of these acts the part of an acid, and the second of a base. The mineral then may be considered as *biselenio-cuprate of silver.*

GENUS XXIV.—MERCURY.

The minerals belonging to this genus are few in number, amounting only to five species. None of them consist of oxygen salts of mercury. Indeed almost all the mercury of commerce is extracted from one ore—cinnabar or sulphuret of mercury.

Sp. 1. *Native Mercury.*

Pure fluid mercury is occasionally met with, though in no great quantity. The most important localities are Idria in Carniola, and Almaden in Spain. It occurs in smaller quantities in the Palatinate, in Hungary, Peru, &c.

Colour tin-white.

Liquid; opaque; lustre metallic.

Specific gravity 13·568.

Entirely volatile before the blowpipe.

Easily soluble in nitric acid.

Consists of pure mercury.

Sp. 2. *Native Amalgam.*

This species is rare, but it occurs occasionally in the Palatinate at Moschellandsberg, and at Rosenau in Hungary. It was found also in the mine of Sala, in Sweden, and it is said also in France and Spain.

Colour silver-white; streak the same.

Massive and crystallized. The primary form is the rhombic dodecahedron. It occurs also in octahedrons. They frequently have their edges replaced by planes, which, when they increase so as to conceal the octahedral planes, convert the crystal into a dodecahedron. Sometimes the edges of the dodecahedron are replaced by one, two or even three planes, and sometimes the alternate angles are replaced by planes.

Lustre metallic.

Opaque; brittle.

Emits a grating noise when cut with a knife.

Hardness 3·25; specific gravity, as determined by Haidinger, 13·755.

Before the blowpipe the mercury is driven off, and a globule of pure silver is obtained.

Two kinds of amalgam have been distinguished; the one solid, the other liquid. The liquid specimens are solutions of the solid amalgam in mercury.

The constitution of this mineral is as follows :—

	*	†
Mercury,	64	72·5
Silver,	36	27·5
	100	100

It is obvious that the composition of the two specimens analyzed is different. Klaproth's specimen was composed of

		Atoms.
Mercury,	5·12	1·96
Silver,	2·61	1

Or of 2 atoms mercury,
1 atom silver.

While Cordier's specimen is composed of

		Atoms.
Mercury,	5·8	2·9
Silver,	2	1

Or of 3 atoms mercury,
1 atom silver.

In fact therefore they constitute two distinct species of amalgam.

Sp. 3. *Sulphuret of Mercury.*

Cinnabar—corallinerz—liver ore.

This species, the most important of all the ores of mercury, occurs chiefly in beds. In this state it is found in gneiss, at Reichenau in Upper Carinthia, and at Hortenstein in Saxony. At Dumbrawa, in Transylvania, it occurs in greywacke. At Hermager, Windisch-Kapell, and other places in Carinthia, it occurs in beds and veins in calcareous spar. But its most important repositories are Idria in Carniola, and Almaden in Spain. In both of these places it seems to occur in bituminous shale. Several other localities may be mentioned, as the Palatinate, Mexico, Peru, China, Japan, &c.

Colour several shades of cochineal red, the darker varieties

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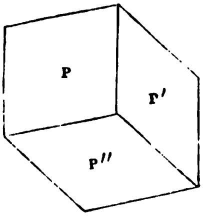
[*] Klaproth, Beitrage, i. 183. [†] Cordier, Phil. Mag. xiv. 41.



inclining to leaden-grey; streak scarlet red.

Massive and crystallized. The primary form of the crystal is an acute rhomboid.

P on P′ 72°

It occurs also in regular six-sided prisms, formed by the lateral angles of the rhomboid being replaced by tangent planes. These, when they increase sufficiently, obliterate the planes of the rhomboid and form the six-sided prism. The angle at the summit and base of the rhomboid is sometimes replaced by six faces, which convert the rhomboid into a crystal with 18 faces. Sometimes both of these replacements appear on the same crystal.

Fracture conchoidal.

Lustre adamantine, inclining to metallic in dark coloured varieties.

Semitransparent, translucent on the edges, or opaque; sectile.

Hardness varies from 1 to 4·25; specific gravity 8·098.

Completely volatile before the blowpipe when pure.

Soluble in nitric acid.

What is called *liver ore*, is merely a compact variety, slightly mixed with foreign matter.

The constituents of this species are as follows:—

	*	†	‡
Mercury,	84·50	85	81·80
Sulphur,	14·75	14·25	13·75
Charcoal,	—	—	2·30
Silica,	—	—	0·65
Alumina,	—	—	0·55
Iron,	—	—	0·20
Copper,	—	—	0·02
Water,	—	—	0·73
	99·25	99·25	100

The mean of these analyses, leaving out the impurities of the liver ore, is as follows:—

		Atoms.
Mercury,	83·8	6·71
Sulphur,	14·25	7·12

---

* Klaproth, Gehlen's Jour. v. 435. Specimen from Japan.

† Klaproth, Ibid. p. 436. Specimen from Neumarktel.

‡ Klaproth, Ibid. p. 440. Liver ore from Idria.

These numbers show obviously that the mineral is composed of

1 atom sulphur,
1 atom mercury.

Or it is a simple sulphuret of mercury.

Sp. 4. *Dichloride of Mercury.*

Corneous mercury—native calomel.

This rare mineral is found occasionally along with cinnabar in secondary rocks. Its chief locality is Moschellandsberg, in Deux Ponts; but it occurs also at Idria, in Carniola, and at Almaden, in Spain.

Colour yellowish-grey or ash-grey; also yellowish and greyish-white; streak white.

It occurs in crusts, and also crystallized in four-sided prisms terminated by pyramids. The primary form is a right square prism. But the lateral edges of the prism are often replaced by tangent planes. The prism is often terminated by a four or eight-sided pyramid.

Lustre adamantine.

Translucent, at least on the edges; sectile.

Hardness 1·5; specific gravity 6·482, as determined by Haidinger.

Before the blowpipe on charcoal is entirely volatilized.

Insoluble in water.

I am not aware that it has been subjected to a rigid analysis, but artificial calomel is composed of

		Atoms.
Chlorine,	15·26	1
Mercury,	84·74	2
	100·00	

And there can be no doubt that the composition of the native mineral is the same.

It is proper, however, to mention that Mr. Woulfe affirms that native calomel generally contains some sulphuric acid.*

Sp. 5. *Chloride of Mercury.*

Native corrosive sublimate.

The existence of this species is affirmed by some mineralogists; but I have never seen a specimen of the mineral, nor met with any description of it.

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* Phil. Trans. 1776, p. 618.

GENUS XXV.—SILVER.

Silver has a strong affinity for sulphur, and it is found very commonly combined with that substance, or in the state of a sulphur salt. In this respect it resembles lead and copper. The sulphur salts of these three genera amount to 16—a greater number than belong to all the other genera united. Silver exists pretty commonly in the native state, but oxygen salts of silver are very rare.

I. *Native, or combined with Simple Bodies.*

Sp. 1. *Native Silver.*

This species occurs chiefly in veins traversing gneiss, clay slate, and other primary and transition rocks. It is found most abundantly in Mexico and Peru. Fine specimens have been taken out of Huel Mexico and Huel Duchy, in Cornwall. Considerable quantities of it occur occasionally in the mining districts of Saxony and Bohemia.

Colour silver, more or less subject to tarnish; streak unaltered, shining.

Massive, in strings and plates. Also crystallized in cubes and regular octahedrons. These crystals are found in great perfection in the mine of Kongsberg, in Norway.

Ductile; opaque.

Hardness 4·25; specific gravity, as determined by Gellert, 10·338.

Native silver consists generally of silver alloyed with copper. That of Curcy, analyzed by Berthier,* is composed of

		Atoms.	
Silver,	90	6·54	2·6
Copper,	10	2·5	1
	100		

Native silver is found in some rare cases alloyed with a notable quantity of gold. In that case the colour is yellowish or greenish-white. Perhaps such combinations ought rather to be referred to native gold than to native silver. The following table exhibits two examples of the constitution of such specimens:

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* Ann. des Mines, xi. 72.

	*	†
Silver,	72 .	36
Gold,	28 .	54
	100	100

The first of these specimens was an alloy of
7 atoms silver,
3 atoms gold;
The second of 3 atoms silver,
5 atoms gold.

This last is doubtless rather a specimen of native gold than native silver.

Sp. 2. *Antimoniet of Silver.*

Antimonial silver ore.

This mineral accompanies the other ores of silver in veins traversing primary and transition rocks. It is not common, but has been found at Andreasberg in the Hartz, in Suabia, at Casalla, near Guadancanal, in Spain, and in other places.

Colour between silver and tin-white.

Usually amorphous, but it has been observed in six-sided prisms, with faces somewhat convex and longitudinally streaked.

Structure foliated; lustre metallic; opaque.

Hardness 3·5; specific gravity, according to Hauy, 9·4406.

Before the blowpipe the antimony evaporates in a grey smoke, and leaves a brownish slag, which tinges borax green. On charcoal the assay leaves finally a globule of silver.

Its constituents are

	‡	‡	§	‖
Silver, .	84 .	76 .	77 .	78
Antimony,	16 .	24 .	23 .	22
	100	100	100	100

It is obvious that the last three specimens belong to the same species; but the proportions in the first analyzed specimen being quite different, it must belong to a different species.

The first is a compound of

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[*] Fordyce, Phil. Trans. 1776, p. 532.

[†] Klaproth, Mohs' Mineralogy, ii. 435.

[‡] Klaproth, Beitrage, ii. 298.

[§] Klaproth, ibid. iii. 175.

[‖] Vauquelin, Hauy, iii. 392.

3 atoms silver,
1 atom antimony.

Or it is a *trisantimoniet of silver*. The second of

2 atoms silver,
1 atom antimony.

Or it is a *diantimoniet of silver*.

The two species analyzed by Klaproth were from Wolfach. He has given no other description of them except that the first is fine granular, and the second coarse granular. The specific gravity of the second species he found 9·820. Perhaps the specific gravity given by Hauy belongs to the first species. At any rate, if any confidence can be put in Klaproth's experiments, two distinct species of antimoniet of silver exist.

Sp. 3. *Arseniet of Silver.*

Arsenical silver ore.

This mineral, about which very little is known, occurs deposited in arsenic at Andreasberg in the Hartz.

Colour nearly that of native silver, but it is commonly tarnished externally of a blackish colour.

It occurs in small globular and reniform masses, which have a curved lamellar structure.

Lustre metallic; opaque; sectile.

Harder than antimoniet of silver.

Specific gravity not determined.

Before the blowpipe arsenical fumes are driven off, leaving a globule of impure silver, surrounded by slag.

Its constituents, according to Klaproth,* are

		Atoms.	
Iron, .	44·25 .	12·64 .	25·3
Arsenic, .	35 .	7·36 .	14·72
Silver, .	12·75 .	0·92 .	1·84
Antimony,	4 .	0·5 .	1
	96		

These numbers do not indicate a chemical compound, but rather a mixture. If we were to suppose the arsenic to be combined with the iron in the ratio of 2 atoms iron to 1 of arsenic, there would remain 2 atoms of arsenic and 1 atom of antimony to combine with 2 atoms of silver, which would make (including the antimony with the arsenic) a sesquiarseniet of silver mixed with a diarseniet of iron. But a new and more accurate analysis would be required before any confidence can be put in such conclusions.

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* Beitrage, i. 187.

Sp. 4. *Bitelluret of Silver.*

This mineral was observed by Messrs. Humboldt, G. Rose and Professor Ehrenberg, in the Museum of Barnaul on the Ob, during a journey which they made some years ago to Siberia. It was found in nests in the new mine Sawodinski, about 40 wersts from the rich silver mine of Siränowski, on the river Buchthorma, in Siberia. The specimens in the Museum consisted of two masses, each about a cubic foot in size. These specimens were found in nests in a rock consisting of talc slate, which contained small quantities of iron pyrites, black blende, and copper pyrites. It was described and analyzed by M. G. Rose.*

Colour intermediate between lead grey and steel grey; lustre metallic, splendent.

Massive; structure coarse granular, without any signs of cleavage.

Malleable, but rather less so than sulphuret of silver.

Hardness 2·25; specific gravity from 8·412 to 8·465.

Before the blowpipe on charcoal it melts to a black globule, and on cooling, white points or dendrites of silver make their appearance on its surface. These appear more readily if the assay be heated by means of the reducing flame. When heated in a glass tube it melts, and gives a yellow colour to the glass. In an open tube it melts also, but a small quantity of a white sublimate rises, which may be made to collect in drops. When fused with biphosphate of soda, the bead, while hot, is transparent, but it becomes opal coloured on cooling. When fused with carbonate of soda, a bead of pure silver is obtained.

Soluble in cold nitric acid, and more rapidly if the acid be heated.

Its constituents are

			Mean.	Atoms.
Silver,	62·42	62·32	62·37	4·53
Tellurium,	36·96	36·89	36·92	9·23
Iron,	0·24	0·50	0·37	
		99·62	99·66	

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* Poggendorf's Annalen, xviii. 64.

These numbers obviously correspond with
2 atoms tellurium,
1 atom silver.
It is therefore a bitelluret of silver.

Sp. 5. *Flexible Sulphuret of Silver.*

Ferro-sulphuret of silver.

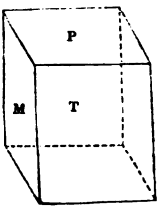
The locality of this mineral, which was first described by Bournon,[*] is not known. Bournon suspected his specimen to be from Hungary. Mr. Brooke has a specimen from Himmelsfurst in Saxony.

Colour nearly black; lustre metallic; opaque.

Massive and in small tabular crystals. The primary form, according to Brooke, is a right oblique-angled prism.

M on T 125°

The edges of the prism, both lateral and terminal, are often replaced by one or two planes.



Composed of thin flexible laminæ.

Very soft, yielding readily to the knife.

According to Dr. Wollaston it is composed of silver, sulphur and a little iron.[†]

Sp. 6. *Sulphuret of Silver.*

Silver glance, vitreous silver, gaserz.

This important species is found almost exclusively in veins, and the rock adjoining the vein is frequently impregnated with it. It occurs in various mines of Saxony and Bohemia; likewise in Hungary, Siberia, Mexico and Peru. It has been met with also in Cornwall, the Hartz, Norway, &c.

Colour blackish lead-grey; streak similar, shining; lustre metallic; opaque.

Massive and crystallized in cubes, regular octahedrons and rhomboidal dodecahedrons. Cleaves parallel to the faces of the cube, which is of course its primary form.

Fracture imperfect small conchoidal; malleable.

Hardness 2·75; specific gravity 7·196.

Fuses easily before the blowpipe and intumesces, but gives a globule of silver, if we continue the blast.

Its constituents, by Klaproth's analysis,[‡] are

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[*] Bournon's Catalogue, p. 209.

[†] Phillips' Mineralogy, p. 289.

[‡] Beitrage, i. 162.

			Atoms.
Silver,	85	6·18	10
Sulphur,	15	7·5	12
	100		

These numbers coincide very nearly with

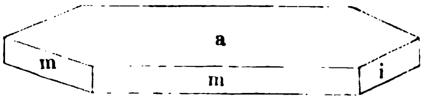
4 atoms sulphuret of silver,
1 atom bisulphuret of silver.

This, if Klaproth's analysis be accurate, must be the constitution of this mineral.

Sp. 7. *Sternbergite.*[*]

This mineral was first described by Mr. Haidinger.[†] It was found in the mines of Joachimsthal in Bohemia, from which it had been obtained many years ago. Fine specimens of it exist in the museum at Prague, and in the possession of M. Neumann, formerly professor of chemistry. It was from these specimens that Mr. Haidinger drew up his description.

Colour dark pinchbeck-brown, nearly resembling the colour of magnetic pyrites, only inclining a little more to black; streak black; lustre metallic, splendent; opaque.



It is usually crystallized, and the primary form seems to be a right oblique prism. T on T′ 120° 15′ A common form is a short six-sided prism, produced by two of the opposite edges of the prism being replaced by a plane. Two of the angles of this prism are 119° 30′ and four 120° 15′. All the crystals observed are modifications of this six-sided prism. Sometimes the terminal edges are replaced by planes. This is the case also with several of the angles.

The cleavage is highly perfect parallel to the face a, but no other cleavage can be observed. The faces a are delicately streaked; they retain their original colour, while the other faces acquire a violet-blue tarnish.

Texture foliated; laminæ flexible; very sectile.

Hardness 1 to 1·5; specific gravity 4·215.

When heated in a glass tube it gives out a strong odour of sulphureous acid, loses its lustre and becomes dark grey and friable. Alone on charcoal it burns with a blue flame and sulphureous odour, and melts into a globule generally hollow, with a crystalline surface and covered with metallic silver. The globule acts strongly on the magnetic needle, and before the blowpipe exhibits all the properties of sulphuret of iron. It communicates to fluxes the ordinary colours produced by iron; red while hot, and yellow on cooling in the oxidizing flame; greenish in the reducing flame. Borax readily removes the iron, and leaves a button of metallic silver.

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[*] Named in honour of Count Sternberg.

[†] Edin. Phil. Trans. xi. 1.

Its constituents, determined by the analysis of professor Zippe* in Prague, are

			Atoms.
Silver,	33·2	2·41	1
Iron,	36·0	10·28	4·26
Sulphur,	30·0	15	6·22
	99·2		

These numbers indicate a compound of

4¼ atoms sulphuret of iron,
1 atom bisulphuret of silver.

Probably the sulphuret of iron acts the part of an acid, and the bisulphuret of silver of a base. If this were the case, the mineral would be a sulphur salt.

Sp. 8. *Seleniet of Silver.*

This mineral was first described and analyzed by M. Gustavus Rose.† It occurs at Tilkerode in the eastern Hartz, and specimens of it were observed by Rose in the Royal Museum of Berlin. The gangue is bitterspar, and it is mixed with seleniet of lead, but easily separated.

Colour iron-black; streak unaltered; lustre metallic, splendent; opaque.

Structure foliated. It exhibits three cleavages perpendicular to each other, so that its primary form is the cube.

The thin plates are covered with a brass-yellow metallic substance, which seems to be copper pyrites.

Malleable, but not so much so as sulphuret of silver.

Hardness 2·5; specific gravity 8·00.

When heated in a glass tube it melts, and gives off a small sublimate, consisting partly of selenium and partly of selenic acid. It gives out a strong smell of selenium. Before the blowpipe, on charcoal, it melts silently in the exterior flame, with frothing in the interior flame. It glows, on cooling, almost as distinctly as magnetic pyrites. With carbonate of soda on charcoal it is reduced. The globule is shining as long as it is hot, but on cooling becomes covered with a black coating; if borax be added, it retains the metallic lustre after cooling. It is silver-white, very malleable, and behaves like pure silver.

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* *Poggendorf's Annalen*, xxvii. 690.

† Ibid. xiv. 471.

Very soluble in smoking nitric acid, but it dissolves with difficulty in dilute nitric acid.

Its constituents are:

		Atoms.
Silver,	65·56	4·76
Lead,	4·91	0·38
Selenium,	25·93	5·18
	96·40	

The atoms of selenium being equal to those of silver and lead together, it is obvious that the mineral is composed of simple seleniets. If the seleniet of lead is not to be reckoned an accidental impurity, the constitution of the mineral is

12 atoms seleniet of silver,
1 atom seleniet of lead.

Sp. 9. *Chloride of Silver.*

Horn silver.

This mineral is most frequently found in the upper part of veins in clay slate, but it occurs also in beds. Formerly it existed in considerable quantity in the Saxon mining districts of Johangeorgenstadt and Freiberg, and also at Joachimsthal in Bohemia. In small quantities, it has been found in Cornwall and in many other localities.

Colour pearl-grey, passing into blue and into greyish, yellowish and greenish-white, and into various shades of green. Becomes brown when exposed to the light.

Massive or investing other minerals; also crystallized in small cubes and acicular prisms. The cube is considered as the primary form.

Lustre resinous, passing into adamantine.

Translucent, at least on the edges.

Sectile.

Hardness 3·5; specific gravity 5·552.

Melts in the flame of a candle.

On charcoal before the blowpipe it is almost entirely reduced. It is reduced also when rubbed wet upon a surface of iron or zinc.

Soluble in ammonia, but not in nitric acid.

Its constituents are

	*	†
Silver,	76	67·75
Chlorine,	24	27·32
Oxide of iron,	—	6·00
Sulphuric acid,	—	0·50
Alumina,	—	1·75
	100	101·30

The first specimen was pure chloride of silver, composed of

1 atom chlorine,
1 atom silver.

The second specimen was obviously contaminated with foreign matter.

Sp. 10. *Iodide of Silver.*

This mineral exists in Mexico, and was recognised by Vauquelin among some specimens which M. Joseph Tabary brought from that country.‡

Colour white, and when the surface was polished it exhibited grains of metallic silver. Its structure was foliated, and the surface of the plates yellowish-green, with some black portions of metallic silver.

Vauquelin subjected it to a chemical examination, and found it to consist of

Silver,
Lead,
Iron,
Iodine,
Sulphur.

But the proportions of each were not determined.

2. *Simple Oxygen Salts of Silver.*

Sp. 1. *Carbonate of Silver.*

This scarce mineral was discovered by Mr. Selb in 1788, in the mine of Winceslas, in Suabia. It is said also to have

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[*] Klaproth, Beitrage, iv. 10. The specimen was from Peru.

[†] Ibid. i. 132.

[‡] Ann. de Chim. et de Phys. xxix. 99.

been observed in veins traversing granite at Altwolfatch, in the Black Forest.

Colour greyish-black; streak bright; lustre metallic; opaque.

Massive; soft; brittle; heavy.

Effervesces with acids; froths when heated with borax.

It has not been analyzed by any modern chemist. Mr. Selb states its constituents to be

Silver,	72·5
Oxide of antimony,	15·5
Carbonic acid,	12·0
	100

But no confidence can be put in this analysis. We may conclude from it, however, that the mineral contains carbonic acid, but whether or not in combination with oxide of silver, remains to be determined.

3. *Sulphur Salts of Silver.*

Sp. 1. *Sulpho-cuprite of Silver.*

Cupreous sulphuret of silver.

This rare mineral has hitherto been found only at Schlangenberge in Siberia, where it occurs mixed with copper pyrites, calcareous spar, &c. It was first examined and recognised as a peculiar species by Stromeyer, from specimens in the museum of Gottingen.*

Colour blackish lead-grey; lustre metallic, splendent; opaque.

Massive; fracture flat conchoidal.

Soft; Bournon describes it as *brittle*, Stromeyer as *sectile*.

Specific gravity 6·258.

Fuses readily before the blowpipe.

Its constituents, as determined by Stromeyer, are

		Atoms.
Sulphur,	15·782	7·84
Silver,	52·272	3·80
Copper,	30·478	7·62
Iron,	0·333	
	98·865	

The atoms of copper being twice those of silver, it is obvious that the mineral is composed of

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* Gilbert's Annalen, liv. 114.

1 atom sulphuret of silver,
2 atoms disulphuret of copper.

If the disulphuret of copper acts the part of an acid, and the sulphuret of silver of a base, the mineral is a *bisulpho-cuprite of silver.*

Sp. 2. *Brittle Silver Glance.*

Trisulpho-antimoniate of silver.

This mineral had been recognised as a subspecies by Werner, but Mohs seems to be the first who accurately described it, under the name of *prismatic melan glance.* It occurs at Schemnitz in Hungary, and in the mines in the neighbourhood of Freiberg.

Colour iron-black; streak unaltered.

Crystals six-sided prisms, terminated by faces perpendicular to the axis. Mohs describes them as four-sided oblique prisms, having the acute edges replaced by faces which render the prism six-sided.

Fracture conchoidal, uneven.

Lustre metallic; opaque; sectile.

Hardness 2·25; specific gravity 6·269.

Before the blowpipe on charcoal it gives a dark coloured metallic bead, which may be reduced either with soda and silica or with saltpetre.

Soluble in dilute nitric acid.

Its constituents, determined by the analysis of Mr. H. Rose,* are

			Atoms.
Sulphur,	16·42	8·21	4·48
Antimony,	14·68	1·83	1
Silver,	68·54	4·98	2·72
Copper,	0·64	0·16	0·09
	100·28		

If we include the copper with the silver, we have nearly three times as many atoms of silver as of antimony. The mineral seems to consist of

1 atom bisulphide of antimony	2 atoms sulphur, 1 atom antimony,
3 atoms sulphuret of silver	3 atoms sulphur, 3 atoms silver.

It is therefore a *trisulphoantimoniate of silver.*

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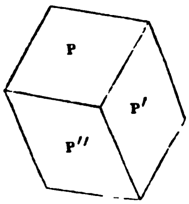
[*] Poggendorf's Annalen, xv. 475.

Sp. 3. *Dark Red Silver Ore.*

Ruby silver, black silver—aerosite, rothgiltigerz—subsesquisulpho-antimoniate of silver.

This beautiful mineral has hitherto been found only in veins. The Saxon and Bohemian mines, and those of Mexico and Peru yield it in considerable quantities, and it has been found in smaller quantities in many other localities.

Colour, by reflected light, varies from lead-grey to iron-black, by transmitted light from brilliant to dark red; streak cochineal and aurora red.



Massive and crystallized in a great variety of forms. Its primary crystal is an obtuse rhomboid.

P on P' 109° 56′, according to Brooke,
108° 30′, according to Phillips.

It occurs also in six-sided prisms, and with a six-sided prism interposed between the two halves of the rhomboid, which constitute a triangular pyramid at either extremity. Also in triangular dodecahedrons, or with a six-sided prism interposed between the pyramids, and in various other forms which have been figured by Hauy and by Phillips.

Lustre metallic, adamantine.

Translucent to opaque.

Hardness 2·25; specific gravity from 5·8 to 5·9.

Decrepitates before the blowpipe on charcoal, melts and emits fumes of sulphur and antimony, after which a globule of silver remains.

For the first accurate analysis of this ore, we are indebted to Bonsdorf.* He found its constituents

		Atoms.	
Silver,	58·949	4·28	1·5
Antimony,	22·846	2·856	1
Sulphur,	16·609	8·304	2·9
Earthy matter,	0·299		
	98·703		

These numbers obviously agree with
3 atoms sulphur,
1½ atom silver,
1 atom antimony.

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* Kong. Vet. Acad. Handl., 1821, p. 338.

We may consider the mineral as composed of

1 atom sesquisulphide of antimony, $\left\{\begin{array}{l}1\frac{1}{2}\text{ sulphur,}\\ 1\text{ antimony,}\end{array}\right.$

$1\frac{1}{2}$ atoms sulphuret of silver.

It is therefore a *subsesquisulpho-antimoniate of silver.*

Sp. 4. *Miargirite.*[*]

Bisulpho-antimoniate of silver.

This mineral was first recognised as a peculiar species by Mohs, who distinguished it by the name of *hemiprismatic ruby blende.* It was formerly considered as a variety of *dark red silver ore.* It is exceedingly scarce, the only known specimens being in possession of M. Von Weissenbach, at Freyberg. It is believed to have been found in the mine called Neue Hoffnung Gottes at Braunsdorf, near Freyberg in Saxony.

Colour iron-black; streak dark cherry-red.

The specimen is in crystals, which have the form of a flat four-sided prism, with one of the angles at each base replaced by a triangular face.

Lustre intermediate between metallic and adamantine.

Opaque, except in thin splinters, when it transmits a deep blood-red colour.

Very sectile.

Hardness 2 to 2·5; specific gravity 5·234.

Before the blowpipe it behaves nearly as dark-red silver ore.

Its constituents, as determined by M. H. Rose,[†] are

		Atoms.
Sulphur,	21·95	10·97
Antimony,	39·14	4·89
Silver,	36·40	2·64
Copper,	1·06	0·26
Iron,	0·62	0·17
	99·17	

The atoms of sulphur are to those of antimony and silver nearly as $1\frac{1}{2}$ to 1. Hence the metals are in the state of sesquisulphurets. The atoms of silver are to those of antimony very nearly as 6 to 11. Hence the constitution of miargirite must be

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[*] From μειων, *less*, and ἀϱγυϱος, *silver*, because it contains less silver than some of the other kindred ores.

[†] Poggendorf's Annalen, xv. 469.

11 atoms sesquisulphite of antimony,
6 atoms sesquisulphuret of silver.

It is probably a *bisulpho-antimoniate of silver.*

Sp. 5. *Light red Silver Ore.*

Subsesqui-sulphoarseniate of silver.

Dark and light red silver were considered by Werner as two subspecies. Mohs pointed out differences in the specific gravity, which led him to conclude, that in reality they constitute two distinct species. Bonsdorf demonstrated, that dark red silver ore is a compound of sulphide of antimony and sulphuret of silver; and H. Rose showed that light red silver ore is a compound of sulphide of arsenic and sulphuret of silver. This demonstrates that they constitute two distinct species, and confirms an old remark of Proust, that red silver ore contains arsenic as well as antimony.

Light red silver ore is found most abundantly in the Saxon and Bohemian mines, near the top of the mountains; while the dark red is found most abundantly lower down.

Colour cochineal red; streak light cochineal red.

Crystals, so far as observation goes, have the same shape as those of dark red silver ore.

Lustre adamantine.

Translucent on the edges, or even semi-transparent; sectile.

Hardness 2·25; specific gravity 5·552.

Its constituents, determined by Rose,* are

		Atoms.	
Sulphur,	19·51	9·75	3·07
Antimony,	0·69	0·09	—
Arsenic,	15·09	3·17	1
Silver,	64·67	4·70	1·48
	99·96		

These numbers obviously correspond with

1 atom sesquisulphide of arsenic, { 1½ atom sulphur, 1 atom arsenic,
1½ atom sulphuret of silver, { 1½ atom sulphur, 1½ atom silver.

It is therefore a *subsesqui-sulphoarseniate of silver.*

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* Poggendorf's Annalen, xv. 473.

Sp. 6. *Polybasite.*[*]

This is a new species, formerly confounded with *brittle silver glance*, but first accurately distinguished by M. G. Rose. The specimens hitherto examined, seem to be from Guanaxuato, in Mexico.

Colour iron black; streak unaltered; lustre strongly metallic; opaque.

Usually crystallized; crystals regular six-sided prisms, terminated by bases perpendicular to the axis of the prism; lateral facesstreaked, parallel to the hexahedral periphery of the base. Prisms usually short and tabular.

Fracture uneven; sectile.

Hardness 2·5; specific gravity 6·214.

Polybasite occurs both crystallized and amorphous. It was considered as having the same form as *brittle silver glance*, till Mohs made the remark, that the primary form of this last is an oblique four-sided prism, having the acute edges replaced by triangular faces.

The constituents of polybasite, as determined by H. Rose,[†] are

		Atoms.
Sulphur,	17·04	8·52
Antimony,	5·09	0·64
Arsenic,	3·74	0·78
Silver,	64·29	4·67
Copper,	9·93	2·48
Iron,	0·06	
	100·15	

The atoms of antimony, arsenic, silver and copper, are together equal to those of sulphur. Hence the mineral is composed of simple sulphurets. The atoms of antimony and arsenic together constitute $\frac{1}{5}$th of the atoms of silver and copper. Now the sulphides of antimony and arsenic constitute the acid, and the sulphurets of silver and copper the base.

Hence the constituents are

1 atom sulphides of antimony and arsenic,
5 atoms sulphurets of silver and copper.

In this mineral it is obvious that a portion of the antimony is replaced by arsenic, while a portion of the silver is replaced by copper.

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[*] From πολυς, *many*, and ϐασις, a *base*. [†] Poggendorf's Annalen, xv. 575.

Polybasite might be called a *pentasulpho-antimonite of silver*, if the name were not too unwieldy.

GENUS XXVI.—URANIUM.

Uranium is rather a scarce metal. Its ores are by no means numerous, and hitherto they consist either of the oxide of the metal mechanically mixed with other bodies, or combined with an acid, and constituting a salt.

Sp. 1. *Pitch Ore of Uranium.*

Pitch blende—pech uran—uran pecherz—uran oxydulé—protoxide of uranium.

The chief localities of this mineral are Johangeorgenstadt, Marienberg, Annaberg and Schneeberg, in Saxony; and Joachimsthal and Fribus, in Bohemia. In Cornwall it has been observed in Tincroft mine and Tollcarn mine.

Colour greyish-black, inclining sometimes to iron black; also greenish and brownish-black.

Massive and pulverulent, but never hitherto observed in crystals.

Fracture conchoidal, uneven.

Lustre imperfect metallic; brittle.

Hardness 3·5; specific gravity 6·468.

Alone it is infusible before the blowpipe, but melts with borax into a grey scoria.

When in the state of powder dissolves slowly, but partially in nitric acid.

This mineral is rather a mechanical mixture than a chemical compound; for not merely the proportions, but even the ingredients differ in different specimens. Klaproth found oxide of uranium, sulphuret of lead, silica and peroxide of iron.*

Arfvedson, besides these constituents, found plenty of arsenic, copper, cobalt and zinc. In three specimens which I examined, I found oxide of uranium, oxide of iron, oxides of copper and lead, besides a notable quantity of earthy matter. Some chemists have considered pitch ore as a silicate of uranium, but the ratio of the silica to the oxide of uranium differs so much in different specimens, that it is impossible to consider them as chemically combined. Selenium has been announced as a constituent of this ore, but Kersten has shown that this substance does not exist in the pitch ore, but in the copper pyrites which is occasionally mixed with it.*

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* Beitrage, ii. 221.

Sp. 2. *Sulphated Protoxide of Uranium.*

This mineral is said to occur near Joachimsthal, in Bohemia, in Elias mine. It was discovered by John.

Colour beautiful emerald green, sometimes passing into apple green.

Crystallized in flattened prisms from 1 to 3 lines in length, arranged in eccentric druses.

Lustre vitreous.

Commonly transparent or translucent, sometimes opaque.

Soluble in water. Solution precipitated chesnut brown by prussiate of potash, yellowish green by alkalies, and in brown flocks by infusion of nutgalls.†

Sp. 3. *Sulphated Peroxide of Uranium.*

This mineral is found in the same place as the preceding. It forms a thin botryoidal, intensely sulphur yellow coloured coating over the surface of the mineral on which it is found.

Friable, and soils the fingers.

Digested in water, a portion dissolves; nitric acid dissolves the rest. Both solutions are yellow coloured.‡

Sp. 4. *Uranite.*

Calcareo-phosphate of uranium—uran mica.

This mineral was discovered by M. Champeaux, at St. Symphorien, near Autun, in veins passing through granite. There are other localities (as near Limoges), but I cannot venture to state them, because this and the following species have been generally confounded together by mineralogists.

Colour fine lemon yellow, gold yellow, and yellowish-brown.

It is found crystallized in four-sided prisms, and in four, six, and eight-sided tables, and sometimes, though rarely, in octahedrons, both obtuse and acute.

Structure lamellar, and it yields with great ease by mechanical division a right square prism, which is its primary form.

Lustre pearly on the face of the prism, adamantine on the other faces.

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* Poggendorf's Annalen, xxvi. 492.

† *Annals of Philosophy* (second series), viii. 390.

‡ Ibid.

Transparent to translucent on the edges; sectile.

Hardness 2·25; specific gravity, as determined by Champeaux, 3·12.

Loses its transparency before the blowpipe. On charcoal melts into a black globule with traces of crystallization on the surface. With borax it yields a yellowish-green bead.

Soluble without effervescence in nitric acid.

Its constituents, as determined by Berzelius,* are

		Atoms.	
Barytes,	1·51	0·16	—
Lime,	5·66	1·61	1·5
Magnesia, Manganese,	0·19	—	—
Peroxide of uranium,	59·37	2·12	1·97
Phosphoric acid,	14·63	3·25	3·02
Water,	14·90	13·24	12·21
Stony matter,	2·70		
Fluoric acid, Ammonia,	trace		
	98·96		

These numbers obviously indicate

1^1 atom lime,
2 atoms peroxide of uranium,
3 atoms phosphoric acid,
12 atoms water.

The constitution of the mineral is therefore

2 atoms phosphated peroxide of uranium,
1 atom subsesquiphosphate of lime,
12 atoms water.

Sp. 5. *Chalcolite*.†

Cupreo-phosphate of uranium—green uran-mica.

This mineral agrees in its characters with the preceding, with this remarkable exception, that its colour is grass or emerald green.

Fine specimens of it have been found in Gunnis Lake mine, near Callington, and in various other Cornish mines, as Corrarich, Tincroft, Huel Buller, &c.

Its composition was first determined by Mr. R. Phillips.‡

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* Kong. Vet. Acad. Handl., 1823, p. 170.

† From χαλκος, copper, and λιθος, *a stone*.

‡ Annals of Philosophy (second series), v. 57.

Its constituents are as follows:—

	*	†	Mean.	Atoms.	
Phosphoric acid, with arsenic acid,	16	15·56	15·78	3·5	3·01
Peroxide of uranium,	60	60·25	60·125	2·14	1·84
Oxide of copper, .	9	8·44	8·72	1·74	1·5
Water, . . .	14·5	15·05	14·77	13·12	11·31
Stony matter, . .	0·5	0·70	0·60		
	100	100			

These numbers evidently lead to

3 atoms phosphoric acid,
2 atoms peroxide of uranium,
1½ atom oxide of copper,
11 atoms water.

Hence the constitution of the mineral is

2 atoms phosphated peroxide of uranium,
1 atom subsesquiphosphate of copper,
11 atoms water.

Or the same as the preceding species, oxide of copper being substituted for lime.

Probably the water in both species is the same, and the chalcolite might have lost a little of its water by exposure to the atmosphere.

GENUS XXVII.—PALLADIUM.

This rare metal has hitherto been found chiefly in South America. It must occur in considerable quantity in Brazil, as in 1825 pretty large ingots of palladium from that country were exposed for sale in London. It has been discovered in Germany in the state of seleniet, though in no great quantity.

Sp. 1. *Native Palladium.*

It occurs in grains, apparently composed of diverging fibres. In other respects these grains differ little from those of native platinum, among which they are found.

Mr. Sowerby describes them as crystallized occasionally in octahedrons and prisms with a square base.

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* Phillips, Annals of Philosophy (second series), v. 57.

† Berzelius, Kong. Vet. Acad. Handl., 1823, p. 174.

Colour steel-grey, inclining to silver-white.

Lustre metallic; opaque.

Hardness greater than that of wrought iron.

Specific gravity, as determined by Mr. Lowry, 12·14; according to Dr. Wollaston, 11·8.

Infusible per se before the blowpipe, but fuses readily with sulphur. By continuing the heat the sulphur is dissipated, and a globule of palladium obtained.

It consists of palladium, alloyed with a little platinum and iridium.

It was discovered by Dr. Wollaston, mixed with grains of native platinum.*

Sp. 2. *Seleniet of Palladium.*

This mineral was discovered in 1829, in the seleniet of lead which exists in considerable quantity at Tilkerode, in the Duchy of Anhalt-Bernborg, in the Hartz. Attempts were made to separate the selenium from the lead, in order to obtain the gold and the silver with which the seleniet was mixed. These attempts were successful. But after the gold had been thrown down from its solution in *aqua regia*, a considerable quantity of palladium was found in the solution. This led Mr. Zinken to examine the seleniet of lead, to discover the state in which the palladium existed in it.

He found that it existed mixed with native gold in the form of small platinum white plates, crystallized in six-sided tables. These plates have a foliated structure, and cleave in a direction parallel to the axis of a six-sided prism.

When heated strongly it becomes coloured, and it is more brittle than any noble metal in a state of purity.

When heated in a tube it gives out selenium. With borax it forms a transparent glass, and gives a brittle metallic globule which, when cupellated with lead, does not change its nature.

By examining it by solution in acids, M. Zinken showed that it is a compound of selenium, palladium, silver and lead. Hence it is probably a triple seleniet of palladium, silver and lead, in proportions not yet determined.†

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* Phil. Trans. 1809, p. 189.

† Zinken, Ann. de Chim. et de Phys. lxiv. 206.

CLASS III.

NEUTRAL BASES.

This class comprehends three metallic bases, which seem neither capable of forming acids nor alkalies by uniting to oxygen or the other supporters of combustion, and which for that reason are denominated *Neutral.* These are *gold*, *platinum*, and *iridium*.

GENUS I.—GOLD.

So far as is known at present, *gold* always occurs in the metallic state, sometimes nearly pure, very frequently alloyed with silver, and sometimes with other metals.

Sp. 1. *Native Gold.*

This mineral occurs both in veins and beds, and is often so minutely disseminated in rocks that it can only be discovered after pounding and washing. In beds it is met with in primary, transition, and secondary rocks. Almost the whole gold of commerce is found in Peru, Mexico, and Brazil, in alluvial soil. Some is found in the same way in Africa. It occurs also in the rivers of France; Spain; at Wicklow in Ireland; at Leadhills; and in Perthshire, it is said, in Glenturrit and Glencoich.

Colour gold-yellow, brass-yellow, greyish-yellow, and greenish-yellow, depending upon the nature of the metals with which it is alloyed.

It is found in threads, plates, and grains, and crystallized in cubes, regular octahedrons, rhomboidal dodecahedrons, and leucite crystals. Sometimes the angles of the cube or octahedron are replaced by tangent planes. Sometimes the faces of the cube, octahedron, and garnet dodecahedron appear altogether on the same crystal. Sometimes the angles of the octahedron are replaced by no fewer than twenty-one small planes, which makes the crystal very complicated.*

Cleavage none; fracture hackly.

Lustre metallic; opaque; ductile.

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* For the best account which I have seen of the crystalline forms of gold and silver, the reader is referred to M. G. Rose, Poggendorf's Annalen, xxiii. 196.

Hardness 3·25.

The specific gravity varies very much according to the quantity of alloy present. The lightest hitherto observed is the native gold of Marmato, composed of 3 atoms gold and 1 atom silver; or,

Gold,	73·45
Silver,	26·48
	99·93

Its specific gravity is only 12·666.* It ought to be, taking the mean of the two constituents, 16·931. The highest specific gravity observed in any specimen of native gold is 19·099. This is that of the native gold of Schabrowski, near Catharinenburg, in Siberia, composed of

Gold,	98·96
Silver,	0·16
Copper,	0·35
Iron,	0·05
	99·52†

Or almost pure gold, since it contains 72 atoms of gold and 1 atom of alloy.

There are no fewer than thirteen different proportions, in which gold and silver are found united in nature, constituting as many different species.

1. A specimen, analyzed by Klaproth, and called by him *electrum*,‡ was composed of

			Atoms.
Gold,	64	5·12	2
Silver,	36	2·61	1
	100		

Boussingault analyzed two specimens of native gold,§ the first from Santa Rosa de Osos, a province of Antioguia, in South America; the second from Transylvania. The constituents were

Gold,	64·93	64·52
Silver,	35·07	35·84
	100·00	100·36

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* Boussingault, Ann. de Chim. et de Phys. xxxiv. 409.

† G. Rose, Poggendorf's Annalen, xxiii. 177.

‡ Beitrage, iv. 1.

§ Ann. de Chim. et de Phys. xxxiv. 416.

These are obviously equivalent to
2 atoms gold,
1 atom silver.

2. Boussingault analyzed three specimens of native gold. The first from Marmato, near La Vega de Sapio, in the Province of Popayan; the second from Titiribi, in South America; the third from Otra-Mina, near Titiribi.[*] The constituents were

Gold,	73·45	74	73·4
Silver,	26·48	26	26·6
	99·93	100	100

These numbers are obviously
3 atoms gold,
1 atom silver.

3. M. G. Rose analyzed a specimen of native gold from Titiribi, in Columbia.[†] Its constituents were

Gold,	76·42
Silver,	23·12
	99·54

This is 3½ atoms gold,
1 atom silver.

4. Boussingault analyzed two specimens of native gold. The first from Trinidad, near Santa Rosa de Osos; the other from Vega de Sucio.[‡] Their constituents were

Gold,	82·4	82·1
Silver,	17·6	17·9
	100·0	100·0

This is obviously 5 atoms gold,
1 atom silver.

5. The three following specimens are composed of

	[§]	[‖]	[‖]
Gold,	84·5	83·85	84·89
Silver,	15·5	16·15	14·68
	100	100	99·53

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[*] Ann. de Chim. et de Phys. xxxiv. 409, 412.

[†] Poggendorf's Annalen, xxiii. 179.

[‡] Ibid.

[§] Boussingault. Ibid. p. 415. The specimen from Ojas Anchas.

[‖] G. Rose. Ibid. p. 174, 180. The first specimen from Boruschka, near Nischne Tagil, Siberia; the second from St. Barbara, Transylvania.

These are composed of

6 atoms gold,
1 atom silver.

6. M. G. Rose analyzed a specimen of native gold from Petropawlowsk, near Bogoslowsk.[*] Its constituents were

Gold,	86·81
Silver,	13·19
	100

This approaches

7 atoms gold,
1 atom silver.

7. The specimens composed of 8 atoms gold and 1 atom silver are the most abundant. The following analyses may serve as examples:—

	[†]	[†]	[†]	[†]	[‡]	[‡]	[‡]	[‡]	[‡]	[‡]
Gold,	88·24	87·94	88·50	88·15	89·35	88·65	87·40	87·31	87·17	87·70
Silver,	11·76	12·06	11·42	11·85	10·65	10·64	12·07	12·12	12·41	12·30
	100	100	100	100	100	99·29	99·47	99·43	99·58	100

These analyses indicate

8 atoms gold
1 atom silver.

8. The following analysis of a native gold from Borowschka is by G. Rose:—

Gold,	90·76
Silver,	9·02
	99·78

It indicates

11 atoms gold,
1 atom silver.

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[*] Poggendorf's Annalen, xxiii. 175.

[†] Boussingault. Ann. de Chim. et de Phys. xxxiv. 408. First specimen from Malpasi; the second from Rio Sucio; the third from Slano; the fourth from Baja.

[‡] G. Rose, Poggendorf, xxiii. 174. The first specimen from Czarewo Nicolajewsk, near Minsk; the second from Newiansk; the third from Alexander Andrejewsk, near Minsk; the fourth from Gozuschka, near Nischne Tagil; the fifth and sixth from the same place.

9. The following analyses are by the same gentlemen:—

	*	*	†	†	†	†	†	†
Gold, .	91·9	91·9	92·60	92·8	92·01	92·47	91·36	91·88
Silver, .	8·1	8	7·08	9·09	7·52	7·47	8·38	8·08
	100	99·9	99·68	101·89	99·53	99·94	99·74	99·96

These specimens were composed of

12 atoms gold,
1 atom silver.

10. The following analyses of specimens of native gold from Catherinenburg and Beresow, are by G. Rose:

Gold,	93·34 .	93·78
Silver,	6·28 .	5·94
	99·62	99·72

The constitution is

16 atoms gold,
1 atom silver.

11. We have the analysis of another species by G. Rose from Boruschka, in Siberia:

Gold,	94·41
Silver,	5·23
	99·64

The constitution of this specimen is

20 atoms gold,
1 atom silver.

12. Finally, Boussingault found the native gold from Bucoramanga composed of

Gold, .	98
Silver, .	2
	100

That is

56 atoms gold,
1 atom silver.

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* Boussingault, Ann. de Chim. et de Phys. xxxiv. 408. The first from St. Bartholomé, the second from Girar.

† G. Rose, Poggendorf, Ibid. The first from Perroe Powlowlk, the second from Catherinenburg, the third from Bucharei, the fourth from Czarewo Nicolajewsk, near Minsk, the fifth from Boruschka, and the sixth from Beresow.

It may be worth while to exhibit the composition of these twelve species of native gold in a table.

Let Ag be the symbol for silver, and Au for gold, then the composition may be represented as follows:

$Ag\ Au^{2}$
$Ag\ Au^{3}$
$Ag\ Au^{34}$
$Ag\ Au^{5}$
$Ag\ Au^{6}$
$Ag\ Au^{7}$
$Ag\ Au^{8}$
$Ag\ Au^{11}$
$Ag\ Au^{12}$
$Ag\ Au^{16}$
$Ag\ Au^{20}$
$Ag\ Au^{56}$

Sometimes gold is alloyed with a notable quantity of silver and copper at once. I found the constituents of a specimen of African gold dust, having a specific gravity of 14·4567, as follows:

			Atoms
Gold,	78	6·24	9
Copper,	11·8	2·95	4·27
Silver,	9·48	0·69	1
	99·28		

These numbers agree nearly with

9 atoms gold,
4 atoms copper,
1 atom silver,

Which must have been the constitution of the specimen analyzed.

The greyish-yellow native gold occurring in those small flat grains which are mixed with native platinum, is supposed to contain platinum as a constituent; but I am not aware that this has been verified by direct analysis.

Sp. 2. *White Ore of Tellurium.*

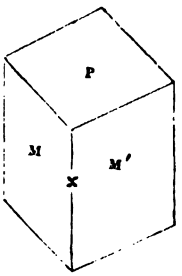
Yellow ore of tellurium.

Hitherto this mineral has been found only at Nagyag in Transylvania.

Colour silver white, much inclining to brass yellow.

Occurs in small but well defined crystals, of which the

primary form is a right rhombic prism,
M on M′ 105° 30′
The edge x is often replaced by a tangent plane, which sometimes is so large as to reduce the faces M, M′ to a very small size, at the same time the terminal edges and angles of the prism are replaced by planes. This converts the crystal into an eight-sided prism, terminated by nine faces.



Traces of cleavage; fracture uneven; lustre metallic; opaque; rather brittle; soft.

Specific gravity, as determined by Muller Von Reichenstein, 10·678.

Before the blowpipe melts into a metallic globule and gives out a pungent smell.

Its constituents, as determined by the analysis of Klaproth,* are

		Atoms.	
Tellurium,	44·75	11·19	18·34
Gold,	26·75	2·14	3·5
Silver,	8·50	0·61	1
Lead,	19·50	1·5	2·45
Sulphur,	0·50	0·25	0·4
	100		

Were we to admit the silver to be in the state of disulphuret, the atoms of gold and lead would be one-third of those of tellurium, while the gold is to the lead as 7 to 5. Hence the mineral would seem to be a compound of
7 atoms tertelluret of gold,
5 atoms tertelluret of lead.

Sp. 3. *Graphic Ore of Tellurium.*

Schrifterz—weiss golderz—aurum graphicum.

This mineral has hitherto been found only in the mine Franciscus at Offenbanya, in Transylvania, in very narrow veins that traverse porphyry, accompanied by quartz and rarely by telluret of lead. The crystals of it are so arranged in the gangue, as to give it the appearance of Persepolitan characters. Hence the origin of the name by which it has been distinguished.

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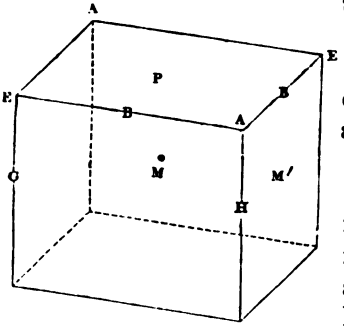
* Beitrage, iii. 28.

Colour pure steel-grey; streak unaltered; lustre metallic; opaque.



Structure foliated, though from the smallness of the crystals this can seldom be perceived. Fracture fine-grained, uneven.

The primary form of the crystal, according to Phillips, is a right rhombic prism.

M on M′ about 107° 44′.

Sometimes the edges B are replaced by faces which obliterate the terminal face, and form a four-sided pyramid with scalene faces. Sometimes the edge H is truncated. The crystals are very small, and so entangled in each other, that it is difficult to make them out.

Hardness 1·5 to 2. The specific gravity is stated by Muller von Reichenstein at 5·723. But this must be considerably under the truth.

Before the blowpipe on charcoal, it fuses into a dark grey metallic globule, which finally becomes brilliant and malleable.

Its constituents, by Berzelius's analysis, are

Tellurium, .	52·00
Silver, . .	11·33
Gold, . .	24·00
Lead, . .	1·50
	88·83

The quantity of matter wanting to make up the hundred parts, consisted of copper, iron, antimony, sulphur, and arsenic.*

The atoms of tellurium are nearly four times as numerous as those of the gold, and silver, and lead. If the mineral be a chemical compound, we must consider it as composed of

2 atoms quarto-telluret of gold,
1 atom quarto-telluret of silver.

GENUS II.—PLATINUM.

This metal, like gold, has hitherto been observed only in the metallic state; though always in combination with various metals. Only one species is at present known.

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* Jahres-Bericht for 1833, p. 162.

Sp. 1. *Native Platinum.*

This mineral has hitherto been found only in grains, some of which are of a large size. It occurs principally in the provinces of Choca and Barbacoas, in South America. Also at Matto Grosso, in Brazil. It has also been found in St. Domingo. It has been found in considerable quantity at Nischne Tagilsk, and Goroblagodat in Siberia, in the Uralian mountains.

Humboldt brought from America, and deposited in the Berlin museum, a mass of native platinum, weighing 1088 grains. Its specific gravity was 18·94. In the year 1822, a mass of native platinum from Condoto, was deposited in the museum at Madrid, 2 inches and 4 lines in diameter, and weighing 11641 grains. But in the year 1827, a mass of native platinum was found in the Ural, not far from the Demidoff mines, weighing 10$\frac{54}{96}$ Russian pounds, or 9·522 lbs. avoirdupois.[*] Its specific gravity was 16.

Colour perfect steel-grey; streak similar.

In irregular grains, sometimes a little convex on one side.

Lustre metallic, shining; opaque; ductile.

Hardness 2·75; specific gravity never exceeds 17·7, usually about 17·332.

Soluble in nitro-muriatic acid, when the action is assisted by heat.

I am not aware that the native platinum from South America has been subjected to a regular analysis; but we have two analyses by Berzelius of the grains of native platinum from Siberia.[†] They are as follows:

	‡	‡	§
Platinum,	78·94	73·58	86·50
Iridium,	4·97	2·35	—
Rhodium,	0·86	1·15	1·15
Palladium,	0·28	0·30	1·10
Copper,	0·70	5·20	0·45
Iron,	11·04	12·98	8·32
Osmium, Iridium,	1·96	—	1·40
Undissolved,	—	2·30	
	98·75	97·86	98·92

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[*] Humboldt, Poggendorf's Annalen. x. 487.

[†] Kong. Vet. Acad. Handl., 1828, p. 113.

[‡] From Nischne Tagilsk. The first specimen consisted of grains attracted by the magnet, the second of grains not affected by the magnet.

[§] The specimen from Goroblagodat.

We have also an analysis of the platinum grains from the Uralian mountains, by M. Osann, professor of chemistry in Dorpat.[*] He obtained

		Atoms.
Platinum,	80·87	6·74
Iron,	10·92	3·12
Palladium,	1·301	0·20
Rhodium,	4·44	0·65
Copper,	2·30	0·6
Osmium,	0·081	
Ruthenium,		
Iridium,		
Silica,		
Iron,	0·027	
Platinum,		
Copper,		
Rhodium,		
	99·939	

The constitution of the specimens analyzed by Berzelius is not very evident. That analyzed by Osann (if we join the palladium to the iron,) would seem to be a compound of

2 atoms platinum,
1 atom iron,

together with a little cupret of rhodium.

We might state the constituents

5 atoms biplatinet of iron,
1 atom cupret of rhodium.

But doubtless, grains of native platinum, like those of native gold, will be found to vary very much in their constitution.

GENUS III.—IRIDIUM.

This metal, like the two preceding, is found only alloyed with other metals. In what state it exists in native platinum has not been determined. But one species of iridium ore was discovered by Dr. Wollaston.

Sp. 1. *Native Iridium.*

Found in grains accompanying the native platinum, both of South America and Siberia.

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[*] Poggendorf's Annalen, xiv. 329.

Colour tin-white, paler than that of native antimony; lustre metallic; opaque; hardness 7.

Usually in small irregular flattened grains. It is sometimes crystallized in six-sided prisms terminated by truncated six-sided pyramids.[*] Brittle.

Hardness 2·75 to 3; specific gravity, as determined by Dr. Wollaston, 19·5; M. G. Rose found a crystal at 52° to be 19·471, that of a crystal from Nischne Tagil, in Siberia, 21·118.

Three different varieties have been described by Berzelius, all from Siberia.

1. The first variety consists of flat plates, which possess two smooth and shining faces, but have no regular form. They never exceed 1 or 2 lines in diameter, and are often much smaller. They are hard enough to scratch glass, and have a specific gravity of 19·25; when heated they give out a little osmium. Their constituents, as analyzed by Berzelius, are

		Atoms.
Iridium,	46·77	3·81
Rhodium,	3·15	—
Iron,	0·74	—
Osmium,	49·34	3·9
Palladium,	trace	
	100·00	or of an atom of each.

2. The second variety resembles the plates from Brazil, which have been already described. Its specific gravity varies from 18·645 to 19·25.

3. The third variety is very rare. It consists of six-sided plates, two of which are larger than the two others. The specific gravity is 21·118. Two kinds of them were analyzed by Berzelius.

The first composed of

Iridium,	25·1	or 1 atom,
Osmium,	74·9	3 atoms.
	100	

The other of

Iridium,	20	or 1 atom,
Osmium,	80	4 atoms.
	100[†]	

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[*] G. Rose, Poggendorf's Annalen, xxix. 452.

[†] Poggendorf's Annalen, xxxii. 232.

APPENDIX.

I HAVE described, in the systematic arrangement, all the minerals which have been subjected to chemical analysis, or of the constitution of which probable conjectures might be formed; but there is a considerable number noticed by crystallographers, which have been met with only in such minute quantity that it has not been in the power of chemists to subject them to analysis, so that their specific characters depend chiefly upon the crystalline form. It will be proper to give a short account of the most important of these minerals by way of Appendix.

Sp. 1. *Brookite.*

Juriuite of Soret.

This mineral was named by Mr. Levy in honour of Mr. Brooke, whose crystallographical labours have conferred so many benefits on mineralogy. It was first noticed by Mr. Soret among the minerals accompanying titanite from Dauphiny; but much finer crystals, some of them half an inch in diameter, were afterwards found at Snowdon, in Wales. These crystals were examined by Mr. Levy, and the measures of the angles determined with great care.*

Colour hair brown, passing into deep orange yellow, with some tints of red; streak yellowish-white.

Crystallized in six-sided prisms, terminated by pyramidal summits. Mr. Levy has shown that the primary form is a right rhombic prism, with angles of 100° and 80°, and whose height is to its breadth as 11 to 30.

Translucent to opaque; brittle.

Hardness 5·5 to 6; specific gravity unknown.

It contains titanium, but its constitution is unknown.

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* *Annals* of Philosophy (second series), ix. 140.

Sp. 2. *Bucklandite.*[*]

Diagonal Scotine of Breithaupt.

This name has been given by Mr. Levy to a mineral from Neskiel, near Arendal, in Norway, deposited in Mr. Turner's collection, and having a good deal of resemblance to pyroxene.

Colour dark brown nearly black.

Crystals usually six-sided prisms, terminated by bihedral summits. Mr. Levy derives them from an oblique rhombic prism, the faces of which are inclined to each other at angles of 70° 40′, and the base is inclined to the lateral faces at an angle of 103° 56′.

Opaque; lustre vitreous.

Fracture uneven.

Specific gravity, according to Mr. G. Rose, 3·945.[†] He found it completely soluble in muriatic acid.

In the collection of Mr. Monrad of Copenhagen, there is a crystal of it about an inch and a half in length, and fully five lines in breadth.[†]

Sp. 3. *Chlorophæite.*

This name has been given by Dr. M'Culloch to a mineral which he found in the Western Isles of Scotland.[‡]

Colour pistachio-green, and transparent, or opaque; but soon becoming brown or black on being exposed to the air without losing its lustre.

Massive; in small grains, imbedded in basalt or amygdaloid, and sometimes hollow.

Fracture conchoidal, nearly earthy.

Brittle; scratched by a quill; specific gravity 2·020.

It occurs in Scuirmore Cliff, in the Island of Rum, also in Fifeshire, and in Iceland.

Sp. 4. *Forsterite.*[§]

This mineral was discovered by Mr. Levy accompanying pleonast and olive-green pyroxene from Vesuvius.

Colourless, brilliant, translucent.

Primary form a right rhombic prism with angles of 128° 54′. The length of a side of the base to the height of the prism as 7 to 4. Cleaves readily parallel to the base.

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[*] Annals of Philosophy (second series), vii. 134.

[†] Allan's Manual of Mineralogy, p. 153.

[‡] M'Culloch's Western Isles, i. 504.

[§] Annals of Philosophy (second series), vii. 61.

Hard enough to scratch quartz.

The angles, as given by Levy, agree nearly with those of chrysoberyl; but no cleavage parallel to the base has been discovered in that mineral.

Sp. 5. *Humite.*

This name was given by Bournon[*] to a mineral from Monte Somma.

Colour various shades of yellow, sometimes almost white, passing into reddish-brown.

In minute very complicated crystals, often macled.

Traces of cleavage parallel to the faces of a six-sided prism.

Lustre vitreous ; brittle ; transparent to translucent.

Hardness 6·5 to 7.

Before the blowpipe becomes opaque, but does not melt. Gives a clear glass with borax.

Sp. 6. *Sommervillite.*[†]

This name has been given by Mr. Brooke to a mineral from the ancient scoriæ of Vesuvius.

Colour pale dull yellow.

In crystals. The primary form seems to be a right rectangular prism; but several of the edges and angles are replaced by new planes. A perfect cleavage parallel to the base of the prism, but in no other direction.

Lustre vitreous.

Decrepitates before the blowpipe, fusing per se into a grey coloured globule, and with borax into a transparent ore.

Sp. 7. *Turnerite.*[‡]

This name has been given by Mr. Levy to a crystallized mineral from Mount Sorel in Dauphiny, which he observed in Mr. Turner's collection.

Colour several shades of yellow, often inclining to brown; streak white, sometimes greyish.

The primary form, according to Levy, is an oblique rhombic prism, the lateral faces of which are inclined at an angle of 96° 10′, and the base to one of the lateral faces at angle of 99° 40′. The ratio between one side of the base and one of the lateral edges, is nearly that of 10 to 7. The only crystal measured by

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[*] Catalogue, p. 52.

[†] Quarterly Journal, xvi. 275.

[‡] *Annals of Philosophy* (second series), v. 241.

Levy is a very complicated one, which could not be understood without a figure.

Lustre nearly adamantine.

Transparent to translucent.

Scratches fluor spar very readily, but yields to the knife.

According to the experiments of Children, it consists chiefly of alumina, lime, magnesia and a little iron, but very little silica and no titanium.

Sp. 8. *Monazite.*[*]

Mengite of Brooke.[†]

This name was given by Breithaupt to a mineral brought by Fiedler from the Uralian mountains. It occurs near Slataoust along with a flesh-red felspar, in an immense bed of granite to the south of the Ilmenn mountain range.

Colour brown or smoky-red; streak reddish-white.

Crystallized in oblique rhombic prisms. The edge of the base is to the height as 13 to 18. The inclination of the faces of the prism is 95° 30′; that of the base on one of the sides 100°, as measured by Brooke.

Lustre vitreous, very small.

Hardness 6; specific gravity 4·88 to 4·922.

Before the blowpipe it does not give out water, nor decrepitate, nor alter its colour. In a white heat the edges become rounded, and the colour becomes greenish-yellow. On charcoal, with carbonate of soda and borax it fuses easily with effervescence in the reducing flame, into a light yellow opaque bead. While hot the bead was dark yellow, but on cooling it became pure yellow and by flaming was rendered opaque, indicating the presence of oxide of uranium. With biphosphate of soda in the oxidizing flame it fuses easily. The bead while hot is yellow, but on cooling it becomes yellowish-green and muddy. In the reducing flame the bead while hot is green, on cooling the colour becomes much deeper, and the bead becomes opaque. From these phenomena it is obvious that monazite contains oxide of uranium, mixed with earthy matter. But I am not aware that it has hitherto been subjected to a chemical analysis.

Sp. 9. *Uwarowite.*[‡]

This name has been given by M. Hess in St. Petersburgh to a mineral from Bissersk, which he examined by the blowpipe.

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[*] Breithaupt, p. 239 and 330. Poggendorf, xxv. 332.

[†] Annals of Philosophy (second series) x. 187.

[‡] Poggendorf's Annalen, xxiv. 388.

Colour emerald-green.

Crystallizes in small rhombic dodecahedrons.

Transparent.

Hardness 7·5.

When heated it does not give out water, nor decrepitate, nor is its colour altered. Not altered per se before the blowpipe. With borax it fuses with difficulty into a clear chrome-green glass; with biphosphate of soda it undergoes decomposition only when in powder. The bead when cold has a fine green colour, and is muddy from interspersed silica. With carbonate of soda it fuses with effervescence into a green frit, which cannot be melted into a bead.

This mineral has a strong resemblance to the *garnet*, but is harder, and of more difficult fusion.

Sp. 10. *Herschellite.**

This name has been given by Mr. Levy to a mineral which occurs in the cavities of trap at Aci Reale, near Catania, in Sicily.

Colour white.

Crystallized in triangular dodecahedrons, the summits of which are deeply truncated. Mr. Levy considers the primary form to be a six-sided prism.

Fracture conchoidal.

Translucent or opaque.

Hardness 4·5; specific gravity 2·11.

Its constituents, according to the trials of Dr. Wollaston, are silica, alumina and potash. It is therefore connected with the felspar tribe of minerals, though its crystalline form differs much from all the kindred bodies.

Sp. 11. *Beudantite.*†

This name has been given by Mr. Levy to a mineral which has been found at Horhausen, in the district of Nassau, on the Rhine.

Colour black.

Translucent in thin fragments, and of a deep brown colour by transmitted light; streak greenish-grey; lustre resinous.

Crystallizes in a slightly obtuse rhomboid, in which the summits are truncated. The inclination of the contiguous edges of the rhomboid is 92° 30′ and 87° 30′. Cleaves easily in the direction perpendicular to the axis of the rhomboid.

Composed, according to Dr. Wollaston, of the oxides of iron and lead.

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* *Annals of Philosophy* (second series), x. 361.

† Ibid. xi. 195.

Sp. 12. *Condurrite.*[*]

This name was given by Mr. W. Phillips to a singular copper ore found in a vein in Cordorrow mine, which is situated in granite, and half a mile south of Dolcoath mine at Redruth, in the county of Cornwall.

Massive; colour brownish-black.

Hard, but not capable of scratching glass.

Brittle; yields to the knife, which leaves a polished metallic-looking surface, nearly of a lead grey colour.

Specific gravity 5·2045.

When ignited it gives out a copious white vapour, leaving on the coal a metallic substance in a semifluid state, of a yellow colour. Its constituents, as determined by the analysis of Mr. Faraday, are as follows:—

		Atoms.
Copper,	60·50	15·12
Sulphur,	3·06	1·53
Arsenic,	1·51	0·31
Arsenious acid,	25·94	4·15
Water,	8·99	8
	100	

There can be little doubt that the arsenious acid had originally existed in this ore in the state of metallic arsenic. The composition was undoubtedly

1 atom sulphuret of copper,
3 atoms arseniet of copper.

The water is no doubt merely mechanical; at first the ore contained a great deal more of it, but by drying it cracked and split into irregular columns like starch.

Sp. 13. *Mohsite.*[†]

This is a name given by Mr. Levy to some crystals upon a group of quartz belonging to Mr. Heuland, and which probably came originally from Dauphiny.

Colour iron-black.

In twin crystals, presenting the aspect of small flat tables nearly circular, with re-entering and salient angles, alternating on their edges. Mr. Levy considers the primary form to be an acute rhomboid of 73° 43′.

Opaque, with a perfect metallic lustre.

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[*] Phil. Mag. (new series), ii. 286.

[†] Ibid. i. 221.

Surface brilliant; fracture conchoidal and shining.

Scratches glass readily.

No visible cleavage; does not affect the magnet; brittle.

It seems to be related to Crichtonite, but has not been subjected to a chemical analysis.

Sp. 14. *Spinellane.*[*]

Nosin, nosiane.

This mineral was discovered by M. Nose on the shores of the lake Loach.

Colour greyish-black, passing into ash-grey and brown.

Crystals rhomboidal dodecahedrons, similar to the form of garnet.

Fracture conchoidal, uneven.

Translucent to opaque.

Hardness 5·5 to 6; specific gravity 2·282.

Before the blowpipe it is infusible, whether alone or with additions.

Its constituents, according to Klaproth, are:

		Atoms.
Silica,	43	26·5
Alumina,	29·5	13·11
Lime,	1·5	0·42
Soda,	19	4·75
Peroxide of iron,	2	0·4
Sulphur,	1	0·5
Water,	2·5	
	98·5	

Or nearly $3AlS^{1\frac{1}{2}}+NS^{1\frac{1}{2}}$.

So that it may be considered as a sesquisilicate of alumina and soda.

Sp. 15. *Okenite.*[†]

This name has been given by Von Kobell to a mineral of which I have only seen a very imperfect description.

Colour yellowish and bluish-white.

Lustre pearly, from shining to glimmering.

Occurs in fibrous masses in amygdaloid.

Hardness stated by Breithaupt from 5 to 8. Specific gravity 2·28.

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[*] Klaproth's Beitrage, vi. 371.

[†] *Breithaupt's Volständige Charakteristik des* Mineral Systems, 127.

Sp. 16. *Breislakite.*[*]

This mineral occurs at Capo di Bove, near Rome, and in the lava of Mount Vesuvius, where it accompanies nepheline, pyroxene, &c.

Occurs in delicate capillary crystals, of a reddish-brown or chesnut-brown colour; bent and grouped like wool, coating the cavities of certain lavas.

It contains silica, alumina, iron and a considerable proportion of copper; affording, when fused with biphosphate of soda, a green globule, which becomes red in the reducing flame.

Sp. 17. *Biotine.*[†]

This mineral was noticed by Monticelli among the volcanic debris of Mount Vesuvius. He named it from M. Biot.

Colour white or yellowish.

Transparent and limpid; refracts doubly.

Lustre brilliant.

Scratches glass.

Specific gravity 3·11.

Is not affected by the blowpipe, and is partially soluble in nitric acid.

Sp. 18. *Tautolite.*[‡]

This mineral is found in the volcanic felspathic rocks in the neighbourhood of the lake Loach in Rhein, Prussia.

Colour velvet-black; streak grey.

Occurs in crystals, and Mohs considers the primary form to be an octahedron with scalene triangles, the three diameters of which are to each other as the numbers 1, 1·9451 and 1·3648. It is usually under the form of a ten-sided prism, with dihedral summits.

Opaque; lustre vitreous; fracture conchoidal.

Hardness 6·5; specific gravity 3·865.

Before the blowpipe upon charcoal it melts into a blackish scoria, which is attracted by the magnet. With borax it melts into a clear green glass.

Tautolite is considered as related to chrysolite, though the degree of relation is not very evident.

Sp. 19. *Tephroite.*[§]

This mineral occurs along with franklinite and red zinc, at Sparta, in the United States of America.

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[*] Allan's Manual of Mineralogy, p. 301.

[†] Ibid, p. 163.

[‡] Phil. Mag. (new series), iii. 398.

[§] Silliman's Jour. xviii. 391.

Colour ash-grey, tarnishing black; streak paler than the mineral.

Massive and compact.

Cleavage perfect in several directions, two of them meeting at right angles.

Fracture imperfect conchoidal, or uneven.

Forms a black slag before the blowpipe.

Sp. 20. *Zurlite.*[*]

This mineral was discovered by Ramondini in 1810, and described by him in the Memoirs of the Academy of Naples. Its only locality is Vesuvius, where it occurs in large distinct crystals generally associated with calcareous spar and other minerals.

Colour asparagus green, inclining to grey.

Crystals rectangular four-sided prisms, having occasionally their lateral edges replaced by tangent planes.

Cleavage indistinct.

Lustre resinous.

Opaque; fracture conchoidal.

Surface of the crystals rough, frequently covered with a white coating.

Hardness about 6; specific gravity 3·27.

Infusible before the blowpipe, but melts with borax into a black glass.

Nitric acid dissolves it partly with effervescence, and the solution is yellow.

Sp. 21. *Hydrous Tris-silicated Peroxide of Iron.*

I have stated in page 476 of this volume, on the authority of a notice from a German mineral dealer, from whom I purchased the specimen, that the mineral on which *cacoxenite* is found at Hrbetk in Bohemia, is a *clay ironstone* occurring in the coal formation. But I have lately procured a specimen of this mineral from Dr. Bondi of Dresden, and have found that it constitutes a new species of iron ore, to which, from its composition, the name of *hydrous tris-silicated peroxide of iron* may be given.

It constitutes an amorphous mass having a brownish red colour, a compact texture, and exhibiting no traces of any tendency to crystallization.

Streak brownish yellow; brittle; opaque.

Fracture uneven.

Hardness 5; specific gravity 3·571.

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[*] Allan's Manual, p. 328.

Before the blowpipe undergoes no change, excepting that the colour becomes dark red.

With carbonate of soda it does not fuse. With borax it fuses readily into a transparent bead, yellow in the oxidizing flame, but becoming almost colourless in the reducing flame. With biphosphate of soda fuses in the oxidizing flame into a transparent bead, yellow while hot but becoming colourless on cooling. The same changes are observable in the reducing flame.

It was subjected to a careful analysis, in my laboratory, by Mr. Richardson, who found its constituents as follows :

			Atoms.
Silica,	10·65	5·32	1
Peroxide of iron,	74·40	14·88	2·80
Lime,	2·25	0·69	0·12
Sesquioxide of mangan.,	0·60	0·12	0·02
Water,	12·00	10·66	2·00
	99·9		

If we unite the lime and sesquioxide of manganese to the peroxide of iron, it is obvious that the constituents are

1 atom silica,
3 atoms peroxide of iron,
2 atoms water.

It is therefore a hydrous *tris-silicated peroxide of iron*. It ought to come in after chloropal in page 463.

Sp. 22. *Rhodizite.*[*]

This mineral was lately observed by M. Gustavus Rose in small crystals on some of the red tourmalins from Siberia.[†]

The crystals observed were small, never exceeding a line in length, and often not so large. They have the form of rhomboidal dodecahedrons, having those angles which consist of three faces replaced by small triangular planes. The faces of the octahedron are also occasionally visible, showing the connexion between the cube, octahedron and rhomboidal dodecahedron.

Colour white; translucent; lustre splendent, vitreous; hard enough to resist the action of the knife ; fracture and specific gravity not determined.

Very difficultly fusible before the blowpipe. A small fragment in the platinum forceps, fused on the edges into a white opaque glass. The colour of the flame is at first green, then the under surface continues green while the upper surface becomes red, and at last the whole flame is tinged red. The red tinge is as deep as that caused by *red* tourmalin, lepidolite, petalite, or spodumen, and is probably induced by the same cause, the existence of *lithia* in the rodizite.

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[*] Named by M. G. Rose from ϱοδιζων, *to have the colour of the rose.* Because it tinges flame red.

[†] Poggendorf's Annalen, xxxiii. 253.

When heated on charcoal its edges are rounded off, it becomes snow-white and opaque, and protuberances make their appearance similar to those which appear when the mineral is exposed to the action of the blowpipe in the platinum forceps.

When heated in a glass tube it gives out no water.

With borax and with biphosphate of soda, it fuses into a transparent glass and appears to contain no silica. With fluor spar it melts into a clear glass. It fuses also completely in silicate of soda without inducing any colour, and therefore contains no sulphuric acid.

With a little carbonate of soda it fuses into a white enamel, which when moistened on a polished silver plate produces no stain. With a greater proportion of the soda it fuses into a clear glass, which does not crystallize on cooling. When the soda glass thus formed is pounded, and dissolved in muriatic acid, and the solution after being evaporated to dryness is digested in alcohol, and the spirit set on fire it burns with as deep a green flame as when *boracite* is treated in the same manner.

Rhodizite dissolves with great difficulty in muriatic acid. A small quantity having been pounded and boiled in muriatic acid left a residue, which would probably have disappeared had the digestion been continued long enough. From the solution ammonia threw down nothing, but oxalate of ammonia occasioned a considerable precipitate. Lithia could not be distinctly recognised in the filtered solution, doubtless from its small quantity.

It is obvious that *rhodizite* has a great resemblance to *boracite*. Its shape, colour, and hardness are analogous, and so are its behaviour before the blowpipe with borax, biphosphate of soda, fluor spar, and silicate of soda. Boracite when heated in the platinum forceps tinges the flame green, and produces a similar precipitate when its muriatic acid solution is treated with oxalate of ammonia. The situation in which rhodizite and boracite are found is different. But a chemical analysis is still wanting to enable us to determine the exact relation in which these two minerals stand to each other.

Sp. 23. *Brevicite.*[*]

This name has been given by Berzelius to a mineral sent him by M. Strom, from Brevig, in Norway, which appears to have filled up an amygdaloidal cavity in a trachyte-looking rock.

It is a white, foliated or radiated mass, which fills the cavity in regular prismatic crystals. It is traversed by dark red and smutty grey red streaks. It was analyzed by M. Sonden in Berzelius's laboratory, who found its constituents to be

		Atoms.	
Silica,	43·88	21·94	33·5
Alumina,	28·39	12·57	19·2
Soda,	10·32	2·58	4
Lime,	6·88	1·96	3
Magnesia,	0·21	0·08	0·12
Water,	9·63	8·56	13·1
	99·31		

These numbers approach

$$19AlS+4NS^2+3CalS^2+13Aq.$$

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[*] From *Brevig*, in Norway, where it was found. See Poggendorf's Annalen, xxxiii. 112.

TABLE

Exhibiting the Specific Gravity, Hardness, and Crystalline Form of Minerals, as far as these properties have been determined.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
CLASS I.			
ACID BASES.			
GENUS I.—CARBON.			
1. Diamond	3·5295	10	Octahedron.
2. Plumbago	2·25—2·32	1	Six-sided prism.
3. Anthracite	1·4—1·75	2	Regular six-sided prism.
4. Bituminous mineral coal			
1. Caking coal	1·269		Cube ?
2. Splint coal	1·29		
3. Cherry coal	1·265		
4. Cannel coal	1·272		
5. Wood coal			
5. Asphalt	1·073—1·205	2	
6. Elastic bitumen	0·9053—1·233		
7. Retinasphaltum	1·135		
8. Scheererite	0·65		Needles.
9. Mineral tallow	0·983		
10. Amber	1·081	2—2·5	
11. Highgate resin	1·046	2·5	

Names.*	Specific Gravity.	Hardness.	Primary Crystalline Form.
GENUS II.—BORON.			
1. Boracic acid	1·439		
GENUS III.—SILICON.			
1. Quartz	2·6413—2·69	7	Rhombohedron, P on P′ 94° 15′.
2. Kilpatrick quartz	2·525	7	
3. Calcedony	2·6	7	Rhombohedron as quartz.
4. Flint	2·575—2·594	7—7·25	
5. Opal	2·015—2·21	6·75	
6. Jasper	2·6		
7. Basanite	2·585—2·644	7	
GENUS IV.—PHOSPHORUS.			
GENUS V.—SULPHUR.			
1. Native sulphur	2·033—2·071	2·5	Rhomboidal octahedron.
GENUS VI.—SELENIUM.			
GENUS VII.—TELLURIUM.			
1. Native tellurium	5·7—6·1	2—2·5	Regular six-sided prism.
GENUS VIII.—ARSENIC.			
1. Native arsenic	5·672	5	
2. Arsenious acid	3·729		Regular octahedron.

Name.	Specific Gravity.	Hardness.	Primary Crystalline Form.
3. Arsenic acid			
4. Sulphide of arsenic . . .	3·642	1·5	Oblique rhombic prism.
5. Sesquisulphide of arsenic . .	3·4—3·48	1·5	Right rhombic prism.
GENUS IX.—ANTIMONY.			
1. Native antimony	6·72	2·5—3	Rhombohedron, P on P′ about 117°
2. Arseniet of antimony . . .	6·13	3·5	
3. Protoxide of antimony . . .	5·566	2·5—3	Rhombic prism, P on P′ 137° 43′
4. Sesquisulphide of antimony . .	4·516—4·62	2	Right rhombic prism.
5. Red antimony	4·09—4·6	1·—1·5	Right square prism.
GENUS X.—CHROMIUM.			
GENUS XI.—MOLYBDENUM.			
1. Bisulphide of molybdenum . .	4·569—4·7385	1—1·5	Regular six-sided prism.
GENUS XII.—TUNGSTEN.			
GENUS XIII.—COLUMBIUM.			
GENUS XIV.—TITANIUM.			
1. Native titanium	5·3	7·5	Cube.
2. Protoxide of titanium . . .	3·826—3·857	5·5—6	Octahedron with square base.
3. Titanic acid	4·18—4·249	6·5—7	Right square prism.
GEUNS XV.—VANADIUM.			

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
CLASS II.			
ALKALINE BASES.			
GENUS I.—AMMONIA.			
1. Sal ammoniac	1·528	1·5—2	Regular octahedron.
2. Sulphate of ammonia	2	1·5	Right square prism.
GENUS II.—POTASSIUM.			
1. Nitrate of potash	1·933		Octahedron with rectangular base.
GENUS III.—SODIUM.			
1. Carbonate of soda	1·622		Oblique rhombic prism.
2. Sesquicarbonate of soda	1·98		Oblique four-sided prism.
3. Nitrate of soda	2·069		Oblique four-sided prism.
4. Hydrous sulphate of soda	1·349		Oblique rhombic prism.
5. Anhydrous sulphate of soda	2·73		Right oblique prism.
6. Borax	1·740		Doubly oblique four-sided prism.
7. Common salt	2·257	2	Cube.
GENUS IV.—LITHIUM.			
GENUS V.—BARIUM.			
1. Carbonate of barytes	4·2985	3·75	Right rhombic prism.

Name.	Specific Gravity.	Hardness.	Primary Crystalline Form.
2. Sulphate of barytes	4·472	3—3·5	Right rhombic prism.
3. Calcareo-sulphate of barytes	4·1907	2·75	Right rhombic prism.
4. Baryto-calcite	3·868	4	
5. Sulphato-carbonate	4·141	3	
			Six-sided prism.
GENUS VI.—STRONTIAN.			
1. Green carbonate of strontian	3·713	3·5	Right rhombic prism.
2. Brown carbonate of strontian	3·651	3—3·5	
3. Sulphate of strontian	3·9626	3—3·5	Right rhombic prism.
4. Baryto-sulphate of strontian	3·921	2·75	
5. Calcareo-sulphate of strontian	3·81	2·75	
6. Stromnite	3·703	3·5	
GENUS VII.—CALCIUM.			
1. Calcareous spar	2·721	3	Obtuse rhombohedron, P on P′ 105° 5′.
2. Arragonite	2·7647—2·9467	3·75	Right oblique prism, M on M′ 116° 10′.
3. Subsesquicarbonate of lime			
4. Hydrous sulphate of lime	2·31—2·3257	2	Right oblique prism.
5. Anhydrous sulphate of lime	2·899—2·957	2·75—3·25	Right rectangular prism.
6. Siliceous sulphate of lime	2·8787	2·75	Right oblique four-sided prism.
7. Subsesquiphosphate of lime	3·0989—3·235	5	Regular six-sided prism.
8. Fluor spar	3·0943—3·1911	4	Regular octahedron.
9. Sesquisilicate of lime		7—7·5	Octahedron with square base.
10. Bisilicate of lime	2·785—2·895	3·—4	Doubly oblique four-sided prism.
11. Wollastonite	2·85—2·876	2·5	

Name.	Specific Gravity.	Hardness.	Primary Crystalline Form.
12. Tersilicate of lime	2·2055	3·5	
13. Dysclasite	2·362	4·25	
14. Sesquihydrous arseniate of lime	2·848	2—2·5	Octahedron with oblique base.
15. Bisesquihydrous arseniate of lime	2·536—2·730	2·5	Right oblique prism.
16. Tungstate of lime	5·959—6·076	6·5	Octahedron with square base.
17. Glauberite	2·73—2·807	2·5—3	Doubly oblique rhomboidal prism.
18. Gaylussite	1·928—1·99	2·5	Doubly oblique prism.
19. Calcareo carbonate of barytes	3·66	4	Oblique rhombic prism.
20. Bicalcareo carbonate of barytes	3·718	2·25	Pyramidal dodecahedron.
21. Baryto fluate of lime	3·75		
22. Xanthite	3·221	2	Doubly oblique prism.
23. Borosilicate of lime	2·98—3·3463	4·25—5	Right rhombic prism.
24. Botryolite	2·885	4	
25. Colophonite	3·871—3·965	6·75	Rhomboidal dodecahedron.
26. Ilvaite	3·825—4·061	4·75—5	Right rhombic prism.
27. Hedenbergite	3·154	3·5	Rhombic prism.
28. Ligurite	3·49	5+	Oblique rhombic prism.
29. Sphene	3·2378—3·510	5—5·5	Oblique rhombic prism.
30. Raphilite	2·85	3·75	Oblique four-sided prism.
31. Polyadelphite	3·767	3·25	
32. Pectolite	2·69	4·5	
GENUS VIII.—MAGNESIUM.			
1. Hydrate of magnesia,	2·35	1	
2. Carbonate of magnesia	2·808—2·95	4·5	

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
3. Hydro-carbonate of magnesia, .			
4. Sulphate of magnesia	1·751	2—2·25	Right rhombic prisms.
5. Reissite			
6. Bloedite			
7. Biborate of magnesia	2·974	4·25	Cube.
8. Hydroboracite	1·9	2	
9. Chrysolite	3·44	6·5—7	Right rectangular prism.
10. Nemalite	2·353—2·44	2	
11. Common serpentine	2·8	3·5	
12. Precious serpentine	2·595 .	3·5	Oblique four-sided prisms.
13. Picrosmine	2·596—2·66	2·5—3	Octahedron.
14. Schiller spar	2·652	3·75	Rhombic prism.
15. Tersilicate of magnesia . . .	2·555—2·594	3·5—4	Doubly oblique prism.
16. Hydrous tersilicate of magnesia .	2·127	2	
17. Magnesite			
18. Quincite			
19. Ferro-carbonate of magnesia . .	3·001—3·112	4—4·5	Rhombohedron.
20. Calcareo-carbonate of magnesia, .	2·815—2·884	3·5—4	Rhombohedron.
21. Wagnerite	3·13	5—5·5	Right oblique prism.
22. Chondrodite	3·118	4·5	Right oblique prism.
23. Potash bisilicate of magnesia . .	2·87		
24. Venetian talc	2·697	1	
25. White augite	3·2307—3·297	4·75	Doubly oblique four-sided prism.
26. Pyroxene	3·233—3·349	4·75	Doubly oblique four-sided prism.
27. Jeffersonite	3·51—3·55	4·5	Doubly oblique four-sided prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
28. Amphibole	2·957—3·2	4·75	Oblique rhombic prism.
29. Norwegian tremolite	3·2	6	
30. Retinalite	2·493	3·75	
31. Hypersthene	3·338—3·385	4·75	Right oblique prism.
32. Humboldilite	3·104		Right square prism.
33. Hyalosiderite	2·875	5·5	Octahedron with rectangular base.
34. Anthophyllite	2·94—3·1558	5—5·5	Right rhombic prism.
35. Mellilite			Square prism.
36. Mountain cork	2·442		
37. Hydrous Anthophyllite	2·911	2·5	
GENUS IX.—ALUMINUM.			
Section I.			
1. Sapphire	3·9511	9	Acute rhombohedron.
2. Spinell	3·523	6	Regular octahedron.
3. Ceylanite	3·575	8	
4. Automalite	4·261	7·25	Regular octahedron.
5. Sapphirine	3·4282	7·75	
6. Candite	3·617	8	
7. Dysluite	4·551	4·5	Regular octahedron.
Section II.			
1. Gibbsite	2·091	2·75	
2. Bihydrate of alumina		3·25	

1.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
3. Diaspore	3·4324		Doubly oblique prism.
4. Mellate of alumina	1·55—1·597	2·75	Octahedron with square base.
5. Aluminite	1·7054	2	
6. Sulphate of alumina . . .	1·666		
7. Fluellite			Right rhombic prism.
8. Turquoise	2·696—3·25	6·75	
9. Andaluzite	3·314	4·25	Right rhombic prism.
10. Hydrous trisilicate of alumina .			
11. Bucholzite	3·193	6	
12. Scarbroite	1·48	3·5	
13. Gilbertite	2·648	2·75	
14. Hydrous bucholzite	2·855	3	
15. Halloylite			
16. Pholerite			
17. Worthite	3·+	7·25	
18. Cyanite	3·618—3·675	6	Doubly oblique four-sided prism.
19. Allophane	1·852—1·889	3	
20. Tuesite	2·558	2·5	
21. Nacrite	2·788—2·793	2·75	Four-sided prism.
22. Fuller's earth	2·4448	1	
23. Davidsonite	2·3629	6·5	Four-sided oblique prism.
24. Lenzenite	1·8—2·1		
25. Quatersilicate of alumina . .	2·688	3	
Section III.			
1. Cryolite	2·949	2·25	Right rectangular prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
2. Topaz	3·449—3·641	8	Right rhombic prism.
3. Pycnite	3·503—3·53	7·5	Six-sided prism.
4. Ambligonite	3·—3·04	6	Rhombic prism.
5. Fibrolite	3·214	7·25	Right rhombic prism.
6. Nepheline	3·27	2·5	Regular six-sided prism.
7. Sodalite	2·295—2·378	5·75	Rhomboidal dodecahedron.
8. Idocrase	3·349—3·599	6	Right square prism.
9. Grossularite	3·372—3·64	6·75	Rhombic dodecahedron.
10. Melanite	3·157—3·73	6·75	Rhombic dodecahedron.
11. Garnet		6·75	Rhombic dodecahedron.
12. Essonite	3·631	6·5	
13. Brown manganese garnet	3·829	6·75	Four-sided oblique prism.
14. Pyrope	3·78	7·5	Cube.
15. Amphodelite	2·763	4·5	Doubly oblique prism.
16. Zoisite	3·32—3·32707	6·25	Oblique rhombic prism.
17. Meionite or Scapolite	2·612—2·749	4·25	Right square prism.
18. Prehnite	2·9—2·953	5	Right rhombic prism.
19. Anhydrous Scolezite		6	
20. Iolite	2·5969—2·6643	7	Regular six-sided prism.
21. Hydrous Iolite		3·75	Irregular six-sided prism.
22. Staurotide	3·693	6·75	Right rhombic prism.
23. Gehlenite	2·9166—3·029	6·5	Right square prism.
24. Weissite	2·808		
25. Fahlunite	2·62—2·79		
26. Anhydrous Fahlunite	2·632		

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
27. Leucite	2·49	7	Cube.
28. Pipestone	2·606—2·608	1·5	
29. Murchisonite	2·5091	6	Four-sided prism.
30. Gabronite	3		Rectangular prism.
31. Icespar	2·4365		Right oblique four-sided prism.
32. Felspar	2·394—2·581	6	Doubly oblique prism.
33. Glassy felspar	2·576—2·582	6	Doubly oblique prism.
34. Albite	2·608—2·6 9	6	Doubly oblique prism.
35. Anorthite	2·656—2·762	6	Doubly oblique prism.
36. Labradorite	2·691—2·75	6	Doubly oblique prism.
37. Kaolin	2·484		
38. Leelite	2·606	6·25	
39. Spodumene	3·188	6·5	Oblique four-sided prism.
40. Petalite	2·42—2·45	6·5	Oblique four-sided prism.
Section IV.			
1. Ammonia-alum	1·56		Regular octahedron.
2. Potash-alum	1·753	2·75	Regular octahedron.
3. Soda-alum	1·88	3	Regular octahedron.
Section V.			
1. Alumstone	2·7517	3·5	Rhombohedron.
2. Wavellite	2·253—2·337	3·25	Right rhombic prism.
3. Lazulite	3·057	5—55	Right rhombic prism.
4. Blue spar	3·024	5·5—6	Right oblique prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
Section VI.			
1. Stellite	2·612	3·25	Four-sided prism.
2. Thomsonite	2·29—2·36966	4·75	Right rectangular prism with square base.
3. Natrolite	2·139—2·2302	4·5	Right rhombic prism.
4. Mesolite	2·125—2·333		Right rhombic prism
5. Scolezite	2·214—2·27		
6. Zeuxite	3·051	4·25	
7. Ittnerite	2·3854	7	Rhomboidal dodecahedron.
8. Plinthite	2·342	2·75	
9. Bonsdorfite		3·5	Regular six-sided prism.
10. Chalilite	2·252	4·5	
11. Karpholite	2.923—2·9365	2·5	Needles.
12. Antrimolite	2·0964	3·75	
13. Glottalite	2·181	3·5	Regular octahedron ?
14. Harringtonite	2·217	5·25	
15. Soapstone	2·396—2·411		
16. Killinite	2·711	3·5	Rectangular four-sided prism.
17. Lomonite	2·3	3·5	Oblique rhombic prism.
18. Chabasite	2·088—2·7176	3·75	Obtuse rhombohedron.
19. Leveyine	2·161	4	Obtuse rhombohedron.
20. Analcime	2·278	6·25	Cube.
21. Lehuntite	1·953	3·75	
22. Cluthalite	2·166	3·5	Right rectangular prism.
23. Hydrolite	2·054	4	

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
24. Erinite	2·04	1·75	
25. Pyrophyllite			
26. Agalmatolite	2·895	2	
27. Stilbite	2·133—2·161	3·5	Right rhombic prism ?
28. Heulandite	2·195—2·2	3·5	Right oblique prism.
29. Brewsterite	2·432	4·25	Right oblique prism.
30. Harmotome	2·400	4·25	Right rectangular prism.
31. Philipsite		4·25	Right rectangular prism.
32. Morvenite	2·448	4·25	Right rectangular prism.
33. Apophyllite	2·335—2·359	62·5	Right square prism.
34. Rhodalite	2·000	2	
35. Neurolite	2·476	4·25	
36. Comptonite	2·427	5	Right rectangular prism.
37. Hexagonal talc	2·772	1·75	Regular six-sided prism.
38. Chlorite	2·823	1·5	
39. Brown chlorite			
Section VII.			
1. Mica	2·824—3·08	2·5	Oblique rhomboidal prism.
2. Elœolite	2·546—2·618	6	Right rhombic prism.
3. Epidote	3·425—3·46	6	Right oblique prism.
4. Axinite	3·271	7	Doubly oblique prism.
5. Tourmaline	3·076	8	Obtuse rhombohedron.
6. Bytownite	2·801	6	
7. Vermiculite	2·5252	1	

Name.	Specific Gravity.	Hardness.	Primary Crystalline Form.
8. Lithomarge	2·457	2·5	
9. Latrobite	2·8		Doubly oblique prism.
10. Withamite	3·137	6	
11. Isopyre			
12. Kirwanite	2·941	2	
13. Scorilite	1·708	2	
14. Sordawalite	2·58		
15. Cauzeranite	2·69		Oblique rhomboidal prism.
Section VIII.			
1. Gieseckite	2·832		
2. Nutallite	2·748—2·758	3·5	Regular six-sided prism.
3. Phyllite	2·889	7	Right square prism.
4. Huronite	2·8625	5·75	
5. Erlanite	3—3·1	3·25	
6. Pinite	2·7575—2·782	6·25—7	Regular six-sided prism.
7. Glauconite	2·598—2·632		
8. Glaucolite	2·72—2·9	5	Rhombic prism.
9. Mountain leather	1·334		
10. Pearl stone	2·342	6	
11. Saussurite	2·801	7	
12. Pitchstone	2·338—2·3604	6·5	
13. Obsidian	2·363—2·372	6·5	
GENUS X.—GLUCINUM.			
1. Phenakite	2·969	7·25	Rhombohedron.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
2. Euclase	2·907—3·098	7·5	Right oblique prism.
3. Emerald	2·58—2·732	7·5—8	Regular six-sided prism.
4. Chrysoberyl	3·508—3·754	8·5	Right rectangular prism.
GENUS XI.—YTTRIUM.			
1. Phosphate of yttria	4·5577	4·25	Octahedron with square base.
2. Yttrotantalite			
1. Black	5·395	5·5	
2. Yellow	5·882		
3. Brownish-black			
3. Fergusonite	5·8—5·838	5·75	Octahedron.
4. Gadolinite	4·1493—4·1795	8	Oblique rhombic prism.
5. Orthite	3·288	7	
6. Pyrorthite	2·19	2·75	Four-sided prism.
GENUS XII.—CERIUM.			
1. Carbonate of cerium			
2. Cerite	4·912	5·5	
3. Thulite	3·1055	5.5	Oblique prism.
4. Fluate of cerium	4·7	4	Regular six-sided prism.
5. Subsesquisilicate of cerium		5	Rhomboidal dodecahedron.
6. Yttrocerite	3·447	5	Right rhombic prism.
7. Allanite	4·001	6	Right oblique four-sided prism.
8. Pyrochlore	4·206—4·216	5	Regular octahedron.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
GENUS XIII.—ZIRCONIUM.			
1. Zircon	4·681	6·5	Octahedron with square base.
2. Sillimanite	3·1636—3·41	6	Oblique four-sided prism.
3. Aeschynite			
4. Eudyalite	2·9036	6	Rhombohedron.
5. Polymignite	4·806	7 ?	Rhomboidal octahedron.
GENUS XIV.—THORIUM.			
1. Thorite	4·63		
GENUS XV.—IRON.			
Section I.			
1. Native iron	5·95—6·72	4·5	
2. Meteoric iron	7·3		
3. Magnetic iron ore	5·092	5·5—6·5	Regular octahedron.
4. Specular iron ore	5·251	5·5—6·5	Slightly acute rhomboid.
5. Crucite	3·579	3	Oblique four-sided prism.
6. Manganesian iron ore . . .	5·079	7	Octahedron.
7. Franklinite	5·069	6—6·5	Octahedron.
8. Dihydrous peroxide of iron . .	4·375	4·5	Right rhombic prism.
9. Hydrous peroxide of iron . .	3·922—4·04	4·5—5	
10. Magnetic pyrites	4·631	5—6	Regular six-sided prism.
11. Bisulphuret of iron . . .	4·83—5·031	6·5	Cube.
12. Radiated pyrites	4·678—4·847	6	Right rhombic prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
13. Sesquiarseniet of iron	7·228	5—5·5	Octahedron with scalene faces.
Section II.			
1. *Simple Oxygen Salts.*			
1. Carbonate of iron	3·7317—3·829	3—4·5	Obtuse rhombohedron.
2. Junkerite	3·815	3·5	Right oblique prism.
3. Bisulphated peroxide of iron			Regular six-sided prism.
4. Sulphated peroxide of iron			Six-sided prism.
5. Mullicite	1·787	1	
6. Subsesquiphosphate of iron			
7. Vivianite	2·661	1·5—2	Right oblique prism.
8. Diarseniate of iron			
9. Subsesquiarseniate of iron	3	2·5	Cube.
10. Arseniate of iron			
11. Hydrous disilicate of iron	3	2·5	Tetrahedron.
12. Chamoisite	3—3·4		
13. Anhydrous silicate of iron	3·8846	4	Four-sided prism.
14. Cronstedtite	3·348	2·5	Regular six-sided prism.
15. Hedenbergite	3·154	3·5	
16. Chloropal	1·727—2·105	3·5	
17. Titaniate of iron	4·427		
18. Iserine	4·491—4·65		
19. Subsesquititaniate of iron			
20. Crichtonite	3	4·25	Acute rhombohedron.
21. Nigrin	4.445		

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
22. Oxalate of iron?	2·489	2	
2. *Double Oxygen Salts.*			
1. Hydrous carbonate of iron	3·404	3·25	
2. Magnesia carbonate of iron			Rhomboid.
3. Manganeso diphosphate of iron	3·439—3·562	5—5·5	Right rectangular prism.
4. Alumina sulphate of iron		1	
5. Hetopizite	3·524		Rhomboidal prism.
6. Carbono-phosphate of iron	3·71		
7. Scorodite	3·162—3·4	3·5—4	Right rhombic prism.
8. Cacoxenite			
9. Sulpharseniate of iron	2·4		
10. Thraulite			
11. Achmite	3·398	4	Right oblique prism.
12. Krokidolite	3·2	4	
13. Chrome iron ore	4·321	5·5	Regular octahedron.
14. Arfvedsonite	3·369	4·5	Oblique four-sided prism.
15. Knebelite	3·714		
16. Columbite	7·236—7·963	5·25	Right rectangular prism.
17. Wolfram	7·155	5	Right oblique prism.
18. Ilmenite	4·766—4·808	5·75	Rhombohedron.
19. Titaniferous iron ore	4·488—4·789	5—5·5	Rhombohedron.
3. *Triple Oxygen Salts.*			
1. Ankerite	3·080	3·5—4	Rhombohedron.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
2. Pyrosmalite	3·081	4·5	Regular six-sided prism.
3. Commingtonite	3·2014	2·75	
4. Nontronite		1·75	
5. Volkonskoite			
6. Polylite	3·231	6·25	
Section III.			
1. Arsenical pyrites	6·127	4·75	Right rhombic prism.
2. Berthierite			
GENUS XVI.—MANGANESE.			
Section I.			
1. Haussmannite	4·722	4·5—5	Octahedron with square base.
2. Braunite	4·818	6—6·5	Octahedron with square base.
3. Manganite	4·312—4·328	4—4·25	Right rhombic prism.
4. Pyrolusite	4·97	2—2·5	Four-sided prism.
5. Hydrous binoxide of manganese			
6. Hydrous sesquibinoxide of manganese	3·31245	4·25	
7. Varvacite	4·283—4·531	2·5	
8. Psilomelanite	4·145	5—6	
9. Newkirkite	3·824	3—3·5	Rectangular prism.
10. Sulphuret of manganese	3·95—4·014	3·5—4	Cube.
11. Arseniet of manganese	5·55		

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
Section II.			
1. *Simple Oxygen Salts.*			
1. Carbonate of manganese	3·592	3·5	Obtuse rhombohedron.
2 Disilicate of manganese			Octahedron.
3. Silicate of manganese	4·078	6·25	Right oblique prism.
4. Sesquisilicate of manganese	3·586	6·25	Doubly oblique four-sided prism.
5. Bisilicate of manganese	3·538	7	
2. *Double Oxygen Salts.*			
1. Huraulite	2·27		Right oblique prism.
2. Bustamite	3·12—3·25	6·5	
3. Ferruginous silicate of manganese	3·014—3·034	2·5	Obtuse rhombohedron ?
4. Carbo-silicate of manganese	3·1—3·89		
5. Babingtonite			Doubly oblique prism.
3. *Triple Oxygen Salts.*			
1. Helvine	3·166	6·5	Acute rhombohedron.
GENUS XVII.—NICKEL.			
Section I.			
1. Sulphuret of nickel			
2. Arseniet of nickel	7·655	5·5	Six-sided prism.
3. Subsesquiarseniet of nickel			

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
4. Binarseniet of nickel			
5. Antimoniet of nickel			Regular six-sided prism.
Section II.			
1. Diarseniate of nickel			
Section III.			
1. Sulphoarsenite of nickel	6·129	5	
2. Sulphoantimonite of nickel	6·097	5·5	Cube.
GENUS XVIII.—COBALT.			
Section I.			
1. Sesquisulphuret of cobalt			
2. Sesquiarseniet of cobalt			
3. Binarseniet of cobalt	6·466	5·5	Cube.
4. Terarseniet of cobalt	6—6·7	5·5	
5. Cobalt ochre	2·2		
Section II.			
1. Diarseniate of cobalt	2·948		Right oblique prism.
2. Disulphate of cobalt			
Section III.			
1. Sulpho-arsenite of cobalt	6·298	5·5	Cube.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
GENUS XIX.—ZINC.			
Section I.			
1. Blende	4·049	3·75	Rhombic dodecahedron.
2. Voltzine	3·66	4·5	
3. Seleniet of zinc	5·56		
4. Red zinc	5·432	4	Regular six-sided prism.
Section II.			
1. Anhydrous carbonate of zinc . .	4·334—4·442	5	Obtuse rhombohedron.
2. Hydrous dicarbonate of zinc . .	3·584—3·598	2—2·5	
3. Anhydrous silicate of zinc . .	3·935	5	
4. Hydrous silicate of zinc . . .	3·379—3·434	5	Right rhombic prism.
5. Sulphate of zinc	2·036	2—2·5	
6. Hopeite	2·76	2·5	Right oblique prism.
Section III.			
1. Marmatite			
GENUS XX.—LEAD.			
Section I.			
1. Native lead			
2. Protoxide of lead	8·00		Rhombohedron.
3. Sesquioxide of lead			Right oblique prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
4. Sulphuret of lead	7·532—7·652	3	Cube.
5. Supersulphuret of lead	6·713	3	
6. Seleniet of lead	7·187	3	
7. Bitelluret of lead	7·087	1—1·5	Right square prism.
Section II.			
1. Carbonate of lead	6·1465—6·48	3·25	Right rhombic prism.
2. Sulphate of lead	6·259—6·298	2·75	Right rhombic prism.
3. Chromate of lead	6	2·75	Oblique rhombic prism.
4. Melanochroite	5·75		Rhombic prism.
5. Tungstate of lead	8	3	Octahedron with square base.
6. Molybdate of lead	5·706—676	2·75	Octahedron with square base.
7. Trismolybdate of lead	6		
8. Chloride of lead	1·897	2	Acicular crystals.
9. Dichloride of lead	7·0—7·1	2·5—3	Oblique prism.
Section III.			
1. Oxydo-chloride of lead			
2. Cupreo-sulphate of lead	5·3	3	Right oblique prism.
3. Sulphato-carbonate of lead	6·8—7	2—2·5	Doubly oblique four-sided prism.
4. Sulphato-tricarbonate of lead	6·3—6·5	2·5	Acute rhombohedron.
5. Chloro-carbonate of lead	6·056	2·75	Rectangular square prism.
6. Phosphate of lead	6·5781—6·915	2·75	Regular six-sided prism.
7. Vanadiate of lead	6·663	2·75	Regular six-sided prism.
8. Arseniate of lead	6·41	2·75	Regular six-sided prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
9. Cupro-chromate of lead . . .			Rhombohedron.
10. Sex-aluminate of lead . . .		4·5	
Section IV.			
1. Cupreous sulphato-carbonate of lead	6·4	2·5—3	Right rhombic prism.
2. Hediphan		3·5	
Section V.			
1. Zinkinite	5·303	3—3·5	Six-sided prism.
2. Plagionite	5·4	2·5	Octahedron.
3. Jamesonite	5·564	2—2·5	Oblique four-sided prism.
4. Feather ore of lead . . .			
5. Nagyag tellurium ore . . .	6·84		
GENUS XXI.—TIN.			
1. Peroxide of tin	6·55—6·945	6·5	Octahedron with square base.
2. Cupreous sulphuret of tin .	4·35	3·25	Cube.
GENUS XXII.—BISMUTH.			
Section I.			
1. Native bismuth	9·737	3·25	Regular octahedron.
2. Sulphuret of bismuth . .	6·549	2·75	Rhombic prism.
3. Ferruginous arseniate of bismuth .	3·694	5·5	
4. Arsenic glance . .			

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
5. Telluret of bismuth . . .			
6. Oxide of bismuth	4·3611		
Section II.			
1. Carbonate of bismuth . . .			
2. Silicate of bismuth . . .	5·912—6·006	5·5—6	Rhomboidal dodecahedron.
Section III.			
1. Needle ore of bismuth . . .	6·125	5·25	—
GENUS XXIII.—COPPER.			
Section I.			
1. Native copper	8·5844	2·75	Cube.
2. Red oxide of copper	5·992	3·5	Regular octahedron.
3. Black oxide of copper . . .			
4. Disulphuret of copper . . .	5·7022	2·75	Acute rhombohedron.
5. Seleniet of copper			
6. Arseniet of copper . . .	4·5		
Section II.			
1. Anhydrous dicarbonate of copper .	2·62	4·25	
2. Hydrous dicarbonate of copper .	4·008	4	Oblique rhombic prism.
3. Sulphate of copper . . .	2·213	2·25	Doubly oblique prism.
4. Brochantite			

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
5. Tetrasulphate of copper . .			
6. Hydrous diphosphate of copper .	3·6—3·8	4	Right rhombic prism.
7. Pelokonite	2·567	3	
8. Hydrous sub-bisesquiphosphate of copper	4·2	4·75	Oblique rhombic prism.
9. Hydrous sesquisilicate of copper .	5·278	5	Obtuse rhombohedron.
10. Bisilicate of copper . . .	2·159		
11. Hydrous subsesquiarseniate of copper	4·043	4·75	Rectangular four-sided prism.
12. Diarseniate of copper . . .	3·389	3·75	Four-sided prism.
13. Prismatic oliven ore . . .	4·2809	3	Right rhombic prism.
14. Acicular oliven ore . . .	4·192	2·75	Rhombic prism.
15. Copper mica	2·5488	2	Acute rhombohedron.
16. Octahedral arseniate of copper .	2·882—2·926	2·25	Octahedron with rectangular base
17. Copper schaum	3·098	1·25	Octahedron.
Section III.			
1. Hydro-carbonate of copper . .	3·831	4·25	Oblique rhombic prism.
2. Silico-carbonate of copper . .	2·238	3	
Section IV.			
1. Hex-muriate of copper . . .	4·43	2·5	Right rhombic prism.
Section V.			
1. Variegated copper ore . . .	5·003	2·5	Regular octahedron.
2. Copper pyrites	4·159—4·16	2·75	Octahedron with square base.
3. Bournonite	5·766	2·75	Right rectangular prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
4. Grey copper ore	4·798—5·104	2·75	Tetrahedron.
5. Tennantite	4·375	3	Regular octahedron or tetrahedron.
Section VI.			
1. Eukairite			
GENUS XXIV.—MERCURY.			
1. Native mercury	13·568		
2. Native amalgam	13·755	3·25	Rhombic dodecahedron.
3. Sulphuret of mercury . . .	8·098	1—4·25	Acute rhombohedron.
4. Dichloride of mercury . . .	6·482	1·5	Right square prism.
5. Chloride of mercury . . .			
GENUS XXV.—SILVER.			
1. Native silver	10·338	4·25	Cube.
2. Antimoniet of silver . . .	9·4406	3·5	Six-sided prism.
3. Arseniet of silver			
4. Bitelluret of silver . . .	8·412—8·565	2·25	
5. Flexible sulphuret of silver . .			Right oblique-angled prism.
6. Sulphuret of silver . . .	7·196	2·75	Cube.
7. Sternbergite	4·215	1—1·5	Right oblique prism.
8. Seleniet of silver	8	2·5	Cube.
9. Chloride of silver	5·552	3·5	Cube.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
10. Iodide of silver			
Section II.			
1. Carbonate of silver . . .			
Section III.			
1. Sulpho-cuprate of silver . .	6·255		
2. Brittle silver glance	6·269	2·25	Six-sided prism.
3. Dark red silver ore	5·8—5·9	2·25	Obtuse rhombohedron.
4. Miargirite	5·234	2—2·5	Four-sided prism.
5. Light red silver ore	5·552	2·25	Four-sided prism.
6. Polybasite	6·214	2·5	Regular six-sided prism.
GENUS XXVI.—URANIUM.			
1. Pitch ore of uranium	6·468	3·5	
2. Sulphated protoxide of uranium .			
3. Sulphated peroxide of uranium .			
4. Uranite	3·12	2·25	Right square prism.
5. Chalcolite			
GENUS XXVII.—PALLADIUM.			
1. Native palladium	11·8—12·14		
2. Seleniet of palladium . . .			Six-sided prism.

Names.	Specific Gravity.	Hardness.	Primary Crystalline Form.
CLASS III.			
NEUTRAL BASES.			
GENUS I.—GOLD.			
1. Native gold	12·666—19·099	3·25	Cube.
2. White ore of tellurium . . .	10·678		Right rhombic prism.
3. Graphic ore of tellurium . .	5·723	1·5—2	Right rhombic prism.
GENUS II.—PLATINUM.			
1. Native platinum	17·332	2·75	
GENUS III.—IRIDIUM.			
1. Native iridium	19·5	2·75—3	Regular six-sided prism.

TABLE

Exhibiting the Specific Gravity of Minerals.

Specific Gravity.	Names.
0·65	Scheererite.
0·9053—1·233	Elastic bitumen.
0·983	Mineral tallow.
1·46	Highgate resin.
1·073—1·208	Asphalt.
1·081	Amber.
1·135	Retinasphaltum.
1·265	Cherry coal.
1·269	Caking coal.
1·272	Cannel coal.
1·29	Splint coal.
1·334	Mountain leather.
1·349	Hydrous sulphate of soda.
1·4—1·75	Anthracite.
1·439	Boracic acid.
1·48	Scarbroite.
1·528	Sal ammoniac.
1·55—1·597	Mellate of alumina.
1·56	Ammonia-alum.
1·623	Carbonate of soda.
1·666	Sulphate of alumina.
1·7054	Aluminite.
1·708	Scorilite.
1·727—2·105	Chloropal.
1·740	Borax.
1·751	Sulphate of magnesia.
1·753	Potash-alum.
1·787	Mullicite.
1·8—2·1	Lenzinite.
1·852—1·889	Allophane.
1·88	Soda-alum.
1·897	Chloride of lead.
1·9	Hydroboracite.
1·928—1·99	Gaylussite.
1·933	Nitrate of potash.
1·953	Lehuntite.
1·98	Sesquicarbonate of soda.
2	Sulphate of ammonia.
2	Rhodalite.
2·015—2·21	Opal.
2·033—2·071	Sulphur.
2·036	Sulphate of zinc.
2·04	Erinite.
2·054	Hydrolite.

Specific Gravity.	Names.
2·069	Nitrate of soda.
2·088	Chabasite.
2·091	Gibbsite.
2·0964	Antrimolite.
2·125—2·333	Mesolite.
2·127	Hydrous tersilicate of magnesia.
2·133—2·161	Stilbite.
2·139—2·2303	Natrolite.
2·159	Bisilicate of copper.
2·161	Levyine.
2·166	Cluthalite.
2·181	Glottalite.
2·19	Pyrorthite.
2·195—2·2	Heulandite.
2·2	Cobalt ochre.
2·2055	Tersilicate of lime.
2·213	Sulphate of copper.
2·214—2·27	Scolezite.
2·217	Harringtonite.
2·22	Huraulite.
2·238	Silico-carbonate of copper.
2·25—2·32	Plumbago.
2·252	Chalilite.
2·253—2·337	Wavellite.
2·257	Common salt.
2·278	Analcime.
2·29—2·36966	Thomsonite.
2·295—2·378	Sodalite.
2·3	Lomonite.
2·31	Hydrate of magnesia.
2·31—2·3257	Hydrous sulphate of lime.
2·335—2·359	Apophyllite.
2·338—2·3604	Pitchstone.
2·342	Plinthite.
2·342	Pearlstone.
2·353	Nemalite.
2·362	Dysclasite.
2·363—2·372	Obsidian.
2·3629	Davidsonite.
2·385	Ittnerite.
2·394—2·581	Felspar.
2·396—2·411	Soapstone.
2·4	Harmotome.
2·4	Sulpharseniate of iron.
2·42—2·48	Petalite.
2·427	Comptonite.
2·432	Brewsterite.
2·4365	Icespar.
2·442	Mountain cork.
2·4448	Fuller's earth.

Specific Gravity.	Names.
2·448	Morvenite.
2·457	Lithomarge.
2·476	Neurolite.
2·484	Kaolin.
2·489	Oxalate of iron.
2·49	Leucite.
2·493	Retinalite.
2·5091	Murchisonite.
2·525	Kilpatrick quartz.
2·528	Vermiculite.
2·536—2·730	Bisesquihydrous arseniate of lime.
2·546—2·618	Elœolite.
2·5488	Copper mica.
2·558—2·594	Tersilicate of magnesia.
2·558	Tuesite.
2·567	Pelokonite.
2·575—2·594	Flint.
2·57—2·582	Glassy felspar.
2·58	Sordawalite.
2·58—2·732	Emerald.
2·585—2·644	Basanite.
2·595	Precious serpentine.
2·596	Picrosmine.
2·5969—2·6643	Iolite.
2·598—2·632	Glauconite.
2·6	Calcedony.
2·6	Jasper.
2·606—2·608	Pipestone.
2·606	Leelite.
2·608—2·619	Albite.
2·612—2·749	Meconite or scapolite.
2·612	Stellite.
2·62—2·79	Fahlunite.
2·62	Anhydrous dicarbonate of copper.
2·632	Anhydrous fahlunite.
2·6413—2·69	Quartz.
2·648	Gilbertite.
2·652	Schiller spar.
2·656—2·762	Anorthite.
2·661	Vivianite.
2·688	Quatersilicate of alumina.
2·69	Cauzeranite.
2·69	Pectolite.
2·691—2·75	Labradorite.
2·696—3·25	Turquoise.
2·697	Talc.
2·711	Killinite.
2·72—2·9	Glaucolite.
2·721	Calcareous spar.
2·73	Anhydrous sulphate of soda.

Specific Gravity.	Names.
2·73—2·807	Glauberite.
2·748—2·758	Nutallite.
2·7517	Alumstone.
2·7575—2·782	Pinite.
2·76	Hopeite.
2·772	Hexagonal talc.
2·785—2·895	Bisilicate of lime.
2·788—2·793	Nacrite.
2·8	Latrobite.
2·801	Bytownite.
2·801	Saussurite.
2·808	Weissite.
2·808—2·95	Carbonate of magnesia.
2·815—2·884	Calcareo-carbonate of magnesia.
2·823	Chlorite.
2·824—3·08	Mica.
2·832	Gieseckite.
2·848	Sesquihydrous arseniate of lime.
2·85	Raphilite.
2·85—2·876	Wollastonite.
2·855	Hydrous bucholzite.
2·8628	Huronite.
2·87	Potash-bisilicate of magnesia.
2·875	Hyalosiderite.
2·8787	Siliceous sulphate of lime.
2·882—2·926	Octahedral arseniate of copper.
2·885	Botryolite.
2·889	Phyllite.
2·895	Agalmatolite.
2·899—2·957	Anhydrous sulphate of lime.
2·9—2·953	Prehnite.
2·9036	Eudyalite.
2·9076—3·098	Euclase.
2·911	Hydrous anthophyllite.
2·9166—3·029	Gehlenite.
2·923—2·9365	Karpholite.
2·94—3·1558	Anthophyllite.
2·941	Kirwanite.
2·9467	Arragonite.
2·918	Diarseniate of cobalt.
2·949	Cryolite.
2·957—3·2	Amphibole.
2·969	Phenakite.
2·974	Biborate of magnesia.
2·98—3·3463	Borosilicate of lime.
3	Gabronite.
3	Crichtonite.
3	Subsesquiarseniate of iron.
3	Hydrous disilicate of iron.
3—3·04	Ambligonite.

Specific Gravity.	Names.
3—3·4	Chamoisite.
3—3·1	Erlanite.
3·014—3·034	Ferruginous silicate of manganese.
3·001—3·112	Ferro-carbonate of magnesia.
3·024	Blue spar.
3·051	Zeuxite.
3·057	Lazulite.
3·076	Tourmalin.
3·080	Ankerite.
3·081	Pyrosmalite.
3·098	Copper schaum.
3·0943—3·191	Fluor spar.
3·0989—3·235	Subsesquiphosphate of lime.
3·1—3·89	Carbo-silicate of manganese.
3·104	Humboldilite.
3·118	Chondrodite.
3·12	Uranite.
3·12—3·25	Bustamite.
3·13	Magnesite.
3·137	Withamite.
3·154	Hedenbergite.
3·1636—3·41?	Sillimanite.
3·166	Helvine.
3·175—3·73	Melanite.
3·188	Spodumene.
3·193	Bucholzite.
3·2	Norwegian tremolite.
3·2	Krokidolite.
3·2014	Commingtonite.
3·214	Fibrolite.
3·221	Xanthite.
3·2307—3·297	White augite.
3·231	Polylite.
3·233—3·349	Pyroxene.
3·2378—3·510	Sphene.
3·27	Nepheline.
3·271	Axinite.
3·288	Orthite.
3·31245	Anhydrous sesquibinoxide of manganese.
3·314	Andaluzite.
3·32—3·32707	Zoisite.
3·338—3·385	Hypersthene.
3·349—3·599	Idocrase.
3·369	Arfvedsonite.
3·379—3·434	Hydrous silicate of zinc.
3·372—3·64	Grossularite.
3·389	Diarseniate of copper.
3·398	Achmite.
3·4	Worthite.
3·4—3·48	Sesquisulphide of arsenic.

Specific Gravity.	Names.
3·404	Hydrous carbonate of iron.
3·425—3·46	Epidote.
3·4282	Sapphirine.
3·4324	Diaspore.
3·439—3·562	Manganeso-diphosphate of iron.
3·44	Chrysolite.
3·447	Yttrocerite.
3·49	Ligurite.
3·449—3·641	Topaz.
3·503—3·53	Pycnite.
3·508—3·754	Chrysoberyl.
3·51—3·55	Jeffersonite.
3·523	Spinell.
3·524	Hetopizite.
3·5295	Diamond.
3·575	Ceylanite.
3·579	Crucite.
3·584—3·598	Hydrous carbonate of zinc.
3·586	Sesquisilicate of manganese.
3·592	Carbonate of manganese.
3·6—3·8	Hydrous diphosphate of copper.
3·617	Candite.
3·618—3·675	Cyanite.
3·631	Essonite.
3·642	Sulphide of arsenic.
3·651	Brown carbonate of strontian.
3·66	Calcareo-carbonate of barytes.
3·66	Voltzine.
3·693	Staurotide.
3·694	Ferruginous arseniet of bismuth.
3·703	Stromnite.
3·71	Carbono-phosphate of iron.
3·713	Green carbonate of strontian.
3·714	Knebelite.
3·718	Bicalcareo-carbonate of barytes.
3·729	Arsenious acid.
3·7317—3·829	Carbonate of iron.
3·75	Baryto-fluate of lime.
3·767	Polyadelphite.
3·78	Pyrope.
3·81	Calcareo-sulphate of strontian.
3·815	Junkerite.
3·824	Newkirkite.
3·825—4·061	Ilvaite.
3·826—3·857	Anatase.
3·829	Brown manganesian garnet.
3·831	Hydro-carbonate of copper.
3·868	Baryto-calcite.
3·871—3·965	Colophonite.
3·8846	Cronstedtite.

Specific Gravity.	Names.
3·921	Baryto-sulphate of strontian.
3·922—4·04	Hydrous peroxide of iron.
3·935	Anhydrous silicate of zinc.
3·95—4·014	Sulphuret of manganese.
3·9511	Sapphire.
3·9626	Sulphate of strontian.
4·001	Allanite.
4·008	Hydrous dicarbonate of copper.
4·043	Hydrous sub-bisesquiarseniate of copper.
4·049	Blende.
4·078	Silicate of manganese.
4·09—4·6	Red antimony.
4·141	Sulphato-carbonate of barytes.
4·145	Psilomelanite.
4·1493—4·1795	Gadolinite.
4·159—4·16	Copper pyrites.
4·18—4·249	Titanite.
4·1907	Calcareo-sulphate of barytes.
4·192	Acicular oliven ore.
4·2	Sub-bisesquiphosphate of copper.
4·206—4·216	Pyrochlore.
4·215	Sternbergite.
4·261	Automolite.
4·209	Prismatic oliven ore.
4·283—4·831	Varvacite.
4·2985	Carbonate of barytes.
4·3 2—4·328	Manganite.
4·321	Chromiron ore.
4·334—4·442	Anhydrous carbonate of zinc.
4·35	Cupreous sulphuret of tin.
4·3611	Oxide of bismuth.
4·375	Tennantite.
4·375	Dihydrous peroxide of iron.
4·427	Titaniate of iron.
4·43	Hexmuriate of copper.
4·445	Nigrin.
4·472	Sulphate of barytes.
4·488—4·789	Titaniferous iron ore.
4·491—4·65	Iserine.
4·5	Arseniet of copper.
4·516—4·62	Sesquioxide of antimony.
4·551	Dysluite.
4·5577	Phosphate of yttria.
4·569—4·7385	Bisulphide of molybdenum.
4·63	Thorite.
4·631	Magnetic pyrites.
4·678—4·847	Radiated pyrites.
4·681	Zircon.
4·7	Fluate of cerium.
4·722	Haussmanite.

Specific Gravity.	Names.
4·766—4·808	Ilmenite.
4·795—5·104	Grey copper ore.
4·806	Polymignite.
4·818	Braunite.
4·83	Bisulphuret of iron.
4·912	Cerite.
4·97	Pyrolusite.
5·003	Variegated copper ore.
5·069	Franklinite.
5·079	Manganesian iron ore.
5·092	Magnetic iron ore.
5·234	Miargerite.
5·251	Specular iron ore.
5·278	Hydrous sesquisilicate of copper.
5·3	Cupreous sulphate of lead.
5·3	Native titanium.
5·303	Zinkenite.
5·395	Black yttrotantalite.
5·4	Plagionite.
5·432	Red zinc.
5·55	Arseniet of manganese.
5·552	Chloride of silver.
5·552	Light red silver ore.
5·56	Seleniet of zinc.
5·564	Jamesonite.
5·566	Protoxide of antimony.
5·672	Native arsenic.
5·7—6·1	Native tellurium.
5·7022	Disulphuret of copper.
5·706—6·760 ?	Molybdate of lead.
5·723	Graphic ore of tellurium.
5·75	Melanochroite.
5·766	Bournonite.
5·8—5·838	Fergusonite.
5·8—5·9	Dark red silver ore.
5·882	Yellow yttrotantalite.
5·912—6·006	Silicate of bismuth.
5·95—6·72	Native iron.
5·959—6·076	Tungstate of lime.
5·992	Red oxide of copper.
6	Chromate of lead.
6	Trismolybdate of lead.
6—6·7	Terarseniet of cobalt.
6·056	Chloro-carbonate of lead.
6·097	Sulpho-antimonite of nickel.
6·125	Needle ore of bismuth.
6·127	Arsenical pyrites.
6·129	Sulpho-arsenite of nickel.
6·214	Polybasite.
6·255	Sulpho-cuprite of silver.

Specific Gravity.	Names.
6·259—6·298	Sulphate of lead.
6·269	Brittle silver glance.
6·298	Sulpho-arsenite of cobalt.
6·3—6·5	Sulphato-tricarbonate of lead.
6·4	Cupreous sulphato-carbonate of lead.
6·41	Arseniate of lead.
6·465—6·48	Carbonate of lead.
6·466	Binarseniate of cobalt.
6·468	Pitch ore of uranium.
6·482	Dichloride of mercury.
6·549	Sulphuret of bismuth.
6·55—6·945	Peroxide of tin.
6·5781—6·915	Phosphate of lead.
6·663	Vanadiate of lead.
6·713	Supersulphuret of lead.
6·72	Native antimony.
6·8—7	Sulphato-carbonate of lead.
6·84	Nagyag tellurium ore.
7·0—7·1	Dichloride of lead.
7·087	Bitelluret of lead.
7·155	Wolfram.
7·187	Seleniet of lead.
7·196	Sulphuret of silver.
7·228	Sesquiarseniate of iron.
7·2366—7·903	Columbite.
7·3	Meteoric iron.
7·532—7·652	Sulphuret of lead.
7·655	Arseniet of nickel.
9·446	Antimoniet of silver.
9·737	Native bismuth.
10·338	Native silver.
10·678	White ore of tellurium.
11·8—12·14	Native palladium.
12·666—19·099	Native gold.
13·568	Native mercury.
13·755	Native amalgam.
17·332	Native platinum.
19·5	Native iridium.

TABLE

Of the Hardness of Minerals, arranged according to the degree of hardness.

		Hardness.
1.	Plumbago	1
2.	Hydrate of magnesia	1
3.	Venetian talc	1
4.	Fuller's earth	1
5.	Vermiculite	1
6.	Mullicite	1
7.	Red antimony	1—1·5
8.	Bisulphide of molybdenum	1—1·5
9.	Bitelluret of lead	1—1·5
10.	Sternbergite	1—1·5
11.	Sulphuret of mercury	1—4·25
12.	Copper schaum	1·25
13.	Sulphide of arsenic	1·5
14.	Sesquisulphide of arsenic	1·5
15.	Pipestone	1·5
16.	Chlorite	1·5
17.	Dichloride of mercury	1·5
18.	Sal ammoniac	1·5—2
19.	Vivianite	1·5—2
20.	Diarseniate of cobalt	1·5—2
21.	Graphic ore of tellurium	1·5—2
22.	Erinite	1·75
23.	Hexagonal talc	1·75
24.	Nontronite	1·75
25.	Anthracite	2
26.	Asphalt	2
27.	Common salt	2
28.	Sesquisulphide of antimony	2
29.	Hydrous sulphate of lime	2
30.	Xanthite	2
31.	Hydroboracite	2
32.	Nemalite	2
33.	Hydrous tersilicate of magnesia	2
34.	Aluminite	2
35.	Agalmatolite	2
36.	Kirwanite	2
37.	Scorilite	2
38.	Copper mica	2
39.	Sulphate of magnesia	2—2·25
40.	Amber	2—2·5
41.	Native tellurium	2—2·5
42.	Sesquihydrous arseniate of lime	2—2·5

	Hardness.
43. Pyrolusite	2—2·5
44. Hydrous dicarbonate of zinc	2—2·5
45. Sulphate of zinc	2—2·5
46. Sulphato-carbonate of lead	2—2·5
47. Jamesonite	2—2·5
48. Margerite	2—2·5
49. Cryolite	2·25
50. Pinite	2·25
51. Sulphate of copper	2·25
52. Octahedral arseniate of copper	2·25
53. Bitelluret of silver	2·25
54. Brittle silver glance	2·25
55. Dark red silver ore	2·25
56. Light red silver ore	2·25
57. Calcareo phosphate of uranium	2·25
58. Highgate resin	2·5
59. Native sulphur	2·5
60. Wollastonite	2·5
61. Bisesquihydrous arseniate of lime	2·5
62. Hydrous anthophyllite	2·5
63. Tuesite	2·5
64. Nepheline	2·5
65. Karpholite	2·5
66. Mica	2·5
67. Subsesquiarseniate of iron	2·5
68. Hydrous disilicate of iron	2·5
69. Hydrous silicate of iron	2·5
70. Varvasite	2·5
71. Ferruginous silicate of manganese	2·5
72. Hopeite	2·5
73. Sulphato tricarbonate of lead	2·5
74. Plagionite	2·5
75. Muriate of copper	2·5
76. Variegated copper ore	5·5
77. Seleniet of silver	2·5
78. Polybasite	2·5
79. Native antimony	2·5—3
80. Protoxide of antimony	2·5—3
81. Glauberite	2·5—3
82. Picrosmine	2·5—3
83. Cupreous sulphato carbonate of lead	2·5—3
84. Calcareo sulphate of barytes	2·75
85. Baryto sulphate of strontian	2·75
86. Calcareo sulphate of strontian	2·75
87. Siliceous sulphate of lime	2·75
88. Gibbsite	2·75
89. Mellate of alumina	2·75
90. Gilbertite	2·75
91. Nacrite	2·75
92. Potash alum	2·75

	Hardness.
93. Plinthite	2·75
94. Pyrorthite	2·75
95. Commingtonite	2·75
96. Sulphate of lead	2·75
97. Chromate of lead	2·75
98. Molybdate of lead	2·75
99. Chloro-carbonate of lead	2·75
100. Phosphate of lead	2·75
101. Vanadiate of lead	2·75
102. Arseniate of lead	2·75
103. Sulphuret of bismuth	2·75
104. Native copper	2·75
105. Disulphuret of copper	2·75
106. Acicular oliven ore	2·75
107. Copper pyrites	2·75
108. Bournonite	2·75
109. Grey copper ore	2·75
110. Sulphuret of silver	2·75
111. Native platinum	2·75
112. Native iridium	2·75—3
113. Anhydrous sulphate of lime	2·75—3·25
114. Calcareous spar	3
115. Hydrous bucholzite	3
116. Allophane	3
117. Quatersilicate of alumina	3
118. Soda alum	3
119. Sulphuret of lead	3
120. Supersulphuret of lead	3
121. Seleniet of lead	3
122. Tungstate of lead	3
123. Cupreous sulphate of lead	3
124. Pelokonite	3
125. Prismatic oliven ore	3
126. Silico-carbonate of copper	3
127. Tennantite	3
128. Sulphate of barytes	3—3·5
129. Brown carbonate of strontian	3—3·5
130. Sulphate of strontian	3—3·5
131. Newkirkite	3—3·5
132. Zinckinite	3—3·5
133. Bisilicate of lime	3—4
134. Carbonate of iron	3—4·5
135. Polyadelphite	3·25
136. Bihydrate of alumina	3·25
137. Wavellite	3·25
138. Stellite	3·25
139. Huronite	3·25
140. Hydrous carbonate of iron	3·25
141. Carbonate of lead	3·25
142. Cupreous sulphuret of tin	3·25
143. Native bismuth	3·25

	Hardness.
144. Native amalgam	3·25
145. Native gold	3·25
146. Arseniet of antimony	3·5
147. Green carbonate of strontian	3·5
148. Stromnite	3·5
149. Tersilicate of lime	3·5
150. Hedenbergite	3·5
151. Nephrite	3·5
152. Precious serpentine	3·5
153. Alumstone	3·5
154. Bonsdorfite	3·5
155. Glottalite	3·5
156. Killinite	3·5
157. Lomonite	3·5
158. Cluthalite	3·5
159. Stilbite	3·5
160. Heulandite	3·5
161. Gieseckite	3·5
162. Chloropal	3·5
163. Carbonate of manganese	3·5
164. Hedyphan	3·5
165. Red oxide of copper	3·5
166. Antimoniet of silver	3·5
167. Chloride of silver	3·5
168. Pitch ore of uranium	3·5
169. Ferro-carbonate of lime	3·5—4
170. Tersilicate of magnesia	3·5—4
171. Calcareo-carbonate of magnesia	3·5—4
172. Scorodite	3·5—4
173. Sulphuret of manganese	3·5—4
174. Carbonate of barytes	3·75
175. Arragonite	3·75
176. Raphilite	3·75
177. Schiller spar	3·75
178. Retinalite	3·75
179. Hydrous iolite	3·75
180. Antrimolite	3·75
181. Chabasite	3·75
182. Lehuntite	3·75
183. Blende	3·75
184. Diarseniate of copper	3·75
185. Sulphate of barytes and lime	4
186. Fluor spar	4
187. Baryto-carbonate of lime	4
188. Botryolite	4
189. Levyine	4
190. Hydrolite	4
191. Fluate of cerium	4
192. Anhydrous silicate of iron	4
193. Achmite	4
194. Krokidolite	4

	Hardness.
195. Red zinc	4
196. Hydrous diphospate of copper	4
197. Hydrous dicarbonate of copper	4
198. Manganite	4—4·25
199. Ferro-carbonate of magnesia	4—4·5
200. Dysclasite	4·25
201. Biborate of magnesia	4·25
202. Andalusite	4·25
203. Meionite	4·25
204. Zeuxite	4·25
205. Brewsterite	4·25
206. Harmotome	4·25
207. Neurolite	4·25
208. Phosphate of yttria	4·25
209. Crichtonite	4·25
210. Hydrous sesquibinoxide of manganese	4·25
211. Anhydrous dicarbonate of copper	4·25
212. Hydro-carbonate of copper	4·25
213. Native silver	4·25
214. Borosilicate of lime	4·25
215. Carbonate of magnesia	4·5
216. Chondrodite	4·5
217. Jeffersonite	4·5
218. Dysluite	4·5
219. Natrolite	4·5
220. Chalilite	4·5
221. Native iron	4·5
222. Dihydrous peroxide of iron	4·5
223. Arfvedsonite	4·5
224. Pyrosmalite	4·5
225. Voltzine	4·5
226. Sexaluminate of lead	4.5
227. Hydrous peroxide of iron	4·5—5
228. Hausmannite	4·5—5
229. White augite	4·75
230. Pyroxene	4·75
231. Amphibole	4·75
232. Hypersthene	4·75
233. Thomsonite	4·75
234. Arsenical pyrites	4·75
235. Hydrous subbisesquiphosphate of copper	4·75
236. Hydrous subbisesquiarseniate of copper	4·75
237. Ilvaite	4·75—5
238. Native arsenic	5
239. Subsesquiphosphate of lime	5
240. Ligurite	5
241. Prehnite	5
242. Subsesquifluate of cerium	5
243. Yttro cerite	5
244. Pyrochlore	5
245. *Wolfram*	5

		Hardness.
246.	Sulpho-arsenide of nickel	5
247.	Anhydrous carbonate of zinc	5
248.	Anhydrous silicate of zinc	5
249.	Hydrous silicate of zinc	5
250.	Hydrous sesquisilicate of copper	5
251.	Harringtonite	5·25
252.	Columbite	5·25
253.	Needle ore of bismuth	5·25
254.	Sphene	5—5·5
255.	Wagnerite	5—5·5
256.	Anthophyllite	5—5·5
257.	Lazulite	5—5·5
258.	Sesquiarseniate of iron	5—5·5
259.	Manganeso diphosphate of iron	5—5·5
260.	Titaniferous iron ore	5—5·5
261.	Hyalosiderite	5·5
262.	Black yttrotantalite,	5·5
263.	Cerite	5·5
264.	Chrome iron ore	5·5
265.	Arseniet of nickel	5·5
266.	Sulpho-antimonide of nickel	5·5
267.	Sesquiarseniet of cobalt	5·5
268.	Binarseniet of cobalt	5·5
269.	Sulpho-arsenide of cobalt	5·5
270.	Ferruginous arseniet of bismuth	5·5
271.	Sodalite	5·75
272.	Phyllite	5·75
273.	Fergusonite	5·75
274.	Ilmenite	5·75
275.	Magnetic pyrites	5—6
276.	Psilomelanite	5—6
277.	Protoxide of titanium	5·5—6
278.	Silicate of bismuth	5·5—6
279.	Magnetic iron ore	5·5—6·5
280.	Specular iron ore	5·5—6·5
281.	Norwegian tremolite	6
282.	Bucholzite	6
283.	Cyanite	6
284.	Amblygonite	6
285.	Idocrase	6
286.	Anhydrous scolezite	6
287.	Murchisonite	6
288.	Felspar	6
289.	Glassy felspar	6
290.	Albite	6
291.	Anorthite	6
292.	Labradorite	6
293.	Elœolite	6
294.	Epidote	6
295.	Bytownite	6
	Withamite	6

	Hardness.
297. Pearlstone	6
298. Allanite	6
299. Sillimanite	6
300. Eudyalite	6
301. Radiated pyrites	6
302. Franklinite	6—6·5
303. Brownite	6—6·5
304. Zoisite	6·25
305. Leelite	6·25
306. Analcime	6·25
307. Apophyllite	6·25
308. Polylite	6·25
309. Silicate of manganese	6·25
310. Sesquisilicate of manganese	6·25
311. Tungstate of lime	6·5
312. Davidsonite	6·5
313. Essonite	6·5
314. Gehlenite	6·5
315. Spodumene	6·5
316. Petalite	6·5
317. Pitchstone	6·5
318. Obsidian	6·5
319. Zircon	6·5
320. Bisulphuret of iron	6·5
321. Bustamite	6·5
322. Helvine	6·5
323. Peroxide of tin	6·5
324. Opal	6·75
325. Colophonite	6·75
326. Turquoise	6·75
327. Grossularite	6·75
328. Melanite	6·75
329. Brown manganese garnet	6·75
330. Staurotide	6·75
331. Erlanite	6·25—7
332. Titanic acid	6·5—7
333. Quartz	7
334. Kilpatrick quartz	7
335. Chalcedony	7
336. Basanite	7
337. Iolite	7
338. Leucite	7
339. Ittnerite	7
340. Axinite	7
341. Nutallite	7
342. Saussurite	7
343. Orthite	7
344. Polymignite	7?
345. Manganesian iron ore	7
346. Bisilicate of manganese	7
347. Flint	7—7·25

		Hardness.
348.	Sesquisilicate of lime	7—7·5
349.	Automalite	7·25
350.	Worthite	7·25
351.	Fibrolite	7·25
352.	Phenakite	7·25
353.	Native titanium	7·5
354.	Pycnite	7·5
355.	Pyrope	7·5
356.	Euclase	7·5
357.	Sapphirine	7·75
358.	Emerald	7·5—8
359.	Spinell	8
360.	Candite	8
361.	Topaz	8
362.	Tourmaline	8
363.	Gadolinite	8
364.	Chrysoberyl	8·5
365	Sapphire	9
366.	Diamond	10

ERRATA.

Page 24, line 5 from bottom, for " Arsenious acid $\dot{As}$" read " Arsenious acid $\bar{As}$."

Page 24, line 4 from bottom, for " Arsenic acid $\bar{As}$" read " Arsenic acid $\dot{As}$."

The dot in the table of symbols denotes the acid containing the most oxygen, while the line ($\bar{As}$) denotes the acid containing least oxygen united to the same base.

Page 27, line 15, for " $Cal\dot{S} + 1\frac{1}{2}Br\dot{S}$" read " $4\frac{1}{2}Cal\dot{S} + Br\dot{S}$."

Page 28, line 11 from bottom, for " Hemolite" read " Nemalite."

Page 30, line 2 from bottom, for " Trollite" read " Weissite."

Page 40, line 9, for " Nagyag of tellurium ore" read " Nagyag tellurium ore."

Page 125, bottom line, for " 13·21" read " 3·211."

Page 210, delete the lines 9, 10, 11.

Page 333, line 7, for " Box d'Antic" read " Bosc d'Antic."

Page 452, bottom line, for " Fouveroy" read " Fourcroy."

Page 483, line 4 from bottom, for " chromium ore" read " chromiron ore."

END OF VOLUME FIRST.

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